OTTAWA, June 22, 1920.

The Right Hon. Sir GEORGE E. FOSTER, P.C., G.C.M.G.,
Chairman of the Sub-Committee of the Privy Council for
Scientific and Industrial Research, Ottawa.

SIR,—I have the honour of presenting to you my report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1920, as required by the terms of the Act (7-8 George V, Chap. 20), constituting the Council.

I have the honour to be,

Your obedient servant,

A. B. MACALLUM,

Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

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REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

Honorary Advisory Council for Scientific and Industrial Research.

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL.

1. *Meetings of the Council and its Committees.*—Ten meetings of the Council were held during the year, that is, one for every month except August and November which the Administrative Chairman spent in visiting centres in Western Canada to confer there with associate organizations on the work of the Council. The average attendance at these meetings was a high one and a very large amount of work was accomplished, not only on such occasions but also in the intervals between them, by the individual members, in connection with the subjects dealt with by the Council. A number of the various Committees of the Council carried on their work in the intervals also and thus facilitated speedy action on a large number of questions which were referred to them by the Council, and this involved a considerable expenditure of time and energy on the part of the members to which the Administrative Chairman wishes to pay a tribute of appreciation.

The meeting of the Associate Committee of Chemists was held in the Chemical Laboratory of McGill University on May 15, 1919, and was attended by twelve out of the total of twenty members. An abstract of the proceedings of this meeting prepared by the Chairman, Professor R. F. Ruttan, is to be found in Appendix A. Amongst the large number of subjects discussed at this meeting were:—

1. The establishment of a National Research Institute.
2. The establishment of an Employment Bureau for Canadian Chemists.
3. Tax free industrial alcohol.
4. The development of the natural resources of the western provinces.
5. The training of Chemists for the industries.

At this meeting the question of keeping the Committee in thorough touch with the expert professional chemists throughout the Dominion received consideration, and in consequence it was decided that a system of retirement of the members by rotation should be inaugurated. This system of retirement, which was approved by the Research Council, and came into effect in 1919, provides for the retirement annually of five members who are not eligible for reappointment until after the interval of a year. This system will completely recast the membership of the Committee in four years but this may be brought about in a shorter period through deaths and resignations. Reappointments may in a number of cases be advisable which will equate the losses thus sustained and thus provide the continuity of membership necessary to the efficiency of the Committee as an Advisory Organization to the Research Council on chemical questions. In any case it is expected the system of retirement will operate to introduce annually new blood into the Committee and thus keep it in accord with the younger generation of chemists throughout the Dominion.

The Associate Committee on Mining and Metallurgy, met in Toronto on March 9, 1920, with an attendance of eleven out of a membership of twenty-two. A resumé of the proceedings of the meeting is given in Appendix B.

The report of the British Columbia Advisory Committee is given in Appendix C. This Committee has engaged Mr. Horace Freeman as its secretary, who will give special attention to the collection of data bearing on the utilization of the natural resources of British Columbia. He has already presented a report (which appears as Appendix D), on the subject of the utilization of wood waste of that province. He has also given attention to the complex sulphide ore problem which is of special importance to the Slocan district and has recommended that a special investigation be undertaken with a view to finding methods which will render possible the separation of the silver, the lead, the zinc, the copper and the iron of these ores from each other without entailing the loss of either the zinc or the lead in the zinc-lead-silver concentrates from these ores prepared according to the present methods.

2. *The Expenditures of the Council.*—Of the parliamentary vote for the year, $120,000, there was expended $99,872.42, leaving a balance of $20,127.58. The increase over the expenditure of the previous year which was $61,151.62, was due to the fact that, in comparison with that year, the Council was able to carry out a larger part of its programme of work but not to the full extent of its anticipations, for some researches, for which grants were made, could not be undertaken, owing to the lack of qualified research workers although it was able to overtake some of arrears of the programme of the previous year. A larger amount was spent on Bursaries, Studentships, and Fellowships than in the previous year. The number of the holders of these was twenty-six, while for 1918-19 it was only eight. The salaries amounted to $22,034.25, which was less than the amount spent for salaries in the preceding year, which was $22,520.88.

3. *Retirement by Rotation in the Membership of the Council.*—When the Research Council was constituted on November 29, 1916, the appointments to its membership were for an indefinite period, that is, no limit was set to the term of appointment. At the time, it was held by the members that if the Council were to be a permanent body this indefiniteness would have to be reviewed at an early date to guarantee as far as possible that the Council should be constituted to be at all times representative of the interests concerned in scientific and industrial research in the Dominion. It was recognized that members who, for several years after appointment would be able to give valuable service to the Council, might eventually, because of advancing age or declining health or physical vigour, be unable to perform effectively the duties of membership. It was recognized also that it might be advisable to recruit the membership from time to time from the ranks of the younger scientific men of the Dominion who, by reason of the attainments in science, and achievement in scientific research, might be of signal service to the Council as members of it, and be also representative of the oncoming generation of researchers who must be prepared for the responsibilities that they are to assume.

Owing, however, to the pressure of other matters, which concerned the Council at its meetings for the years 1917 and 1918, no action in regard to this was taken, but when, toward the close of 1918, Professor S. F. Kirkpatrick and Mr. T. Bienvenu resigned from the Council, the latter, anticipating a general scheme involving retirement of the members, recommended that their successors, Professor W. L. Goodwin and Sir George Garneau, should be appointed for a term of two years, to which recommendation effect was given by the Order in Council appointing them.

At the twenty-seventh and twenty-eighth meetings of the Council the subject of the retirement of the members of the Council was given extended consideration, and as a result it was decided to recommend to the Sub-Committee of the Privy Council for Scientific and Industrial Research,—

(1) That henceforth appointments to the membership of the Council should be for a three-year term.

(2) That a system of retirement by rotation of the members, based on this limitation of the term of appointment, be at once instituted.

(3) That each member, at the end of his term of appointment, be eligible for reappointment for three years.

(4) That in accordance with this limitation of the term of appointment four members should retire in 1920, three in 1921, and three in 1922, and that thereafter the retirement of the members should follow this order.

In accordance with these recommendations the Council determined the order of retirement of the members according to this plan and included in the list of four who should retire in 1920 the name of Mr. Robert Hobson, M.E., who, because of his duties as member of the Board of Directors of the Canadian National Railways, found himself unable to give much attention to the work of the Council and had, consequently, in 1918, presented his resignation as a member of it, to be accepted as soon as the Council deemed convenient.

The Sub-Committee of the Privy Council approved these recommendations and an Order in Council was passed on March 23 giving effect to them. Accordingly the term of appointment of four members expired on March 31. Three of these, namely Mr. R. A. Ross, E.E., Professor J. C. McLennan, F.R.S., and President Walter C. Murray, were reappointed for three years, and Mr. Lloyd Harris was appointed also for a term of three years to succeed Mr. Robert Hobson, who had resigned.

The system of retirement of the members of the Council by rotation will, it is believed, maintain its efficiency and permit the introduction, as occasion may require, of new members who will be in touch with all the questions involved in the development of scientific and industrial research in Canada. It will provide an opportunity for service to younger scientific men who have won distinction in research.

Since the Council was established three members have retired by resignation, that is, nearly one-third of the membership has changed. It is possible that others may, to the regret of their colleagues, find it necessary to retire and this will, with the retirements due to rotation, very considerably affect the membership of the Council.

4. *Assisted Researches.*—The total amount expended by the Council to assist approved researches was $33,315.53, of which $10,764.47 was for investigations approved in the previous year (1918-19), but which had not then been undertaken because of difficulties in getting the services of assistants or the materials and apparatus required. The number of researches thus aided was fourteen. No part of any one of these grants was expended in paying for the service of the investigator who undertook or superintended the research.

A list of these grants is given in Appendix I. Of these a number deserve special attention. One, that of $1,200, to Professor Alfred Stansfield, of McGill University, was to enable him to continue the research begun in the previous year with the aid of a grant from the Council, on the reduction of iron ores by gases at low temperature and the electric furnace. A full reference to the character of this research is given in the Report of the Administrative Chairman for 1918-19. Professor Stansfield has experimented with the reduction of hematite and magnetite ores by solid reducing reagents (charcoal) and gaseous reagents such as carbon monoxide, hydrogen, water gas and producer gas, both alone and with charcoal. The results so far obtained with the solid reducing agents are very satisfactory and will form a valuable basis for further attempts either on a laboratory or a work scale to construct continuous reducing appliances for iron ore. On some of these findings patents are being applied for in order to permit of their commercial development in Canada.

It cannot be too strongly emphasized that methods which will make the low grade ores of the Dominion economically utilizable are desiderata of the utmost importance

to Canada at the present time. The iron ore, iron and steel and their products annually imported into Canada exceed $150,000,000 in value. Such methods would render the greater part of this importation unnecessary. The Council in supporting such investigations as Professor Stansfield is carrying on is of the opinion that some of the problems which must be solved before such a utilization can be successfully achieved must be attacked on a larger scale than hitherto attempted and it would if it had the funds at its disposal make a provision for such an investigation commensurate with its importance.

A grant of $1,500 was made to Professor C. W. Drury, of Queen's University, to permit of the determination of the most suitable slag for smelting iron ores containing vanadium, in other words the recovery of vanadium and pig-iron together from iron ores containing vanadium (and titanium) by a simple smelting process, instead of by the complicated wet method at present in vogue for producing the alloy ferro-vanadium.

Ores containing vanadium are found at certain points throughout Canada but more especially and in considerable quantities in Central Ontario, where they contain also titanium, the removal of which is difficult and consequently these ores have not been utilized hitherto. The investigation aims at removing the titanium in the slag and obtaining the vanadium in the pig-iron produced in the operation and ultimately vanadium steel, a product with qualities which distinguish it amongst the alloy steels.

A grant of $1,850 was made to Dr. J. A. Gray, of McGill University, to aid in an investigation to determine the character of the most penetrating type of Röntgen Rays and their application as compared with the penetrating rays from radium. This research involves an exploration of a new field and will concern pure Röntgen Rays of definite wave length out of all those which are a mixture of a fairly long spectrum. The ever-increasing importance of the X-rays not only in medical work but also in industrial lines (as for example in study of flaws in metals) render such investigations of great importance.

For a research on the grading of dairy products (cream and butter) a grant of $1,000 was made to Professor Wilfrid Sadler, of the Department of Dairying of the University of British Columbia. This investigation was undertaken to correlate, if possible, the grading of cream and butter with the bacterial content of the milk or cream used in the preparation of these products. It is very probable that the data which will result from this investigation will make possible a uniform and standard system of grading which will determine the keeping qualities of cream and butter from various sources, all in relation to special bacterial forms present. The number of the different forms of bacteria which can and very often do occur in cream after pasteurization, and in butter made therefrom is very great (more than 250) and this recontamination is of critical importance to the dairying industry.

A grant of $5,000 was made to Professor J. C. McLennan for assistance in investigating the properties of helium to determine its uses for lamps of various kinds, amplifying valves, high resistances, etc. This investigation will also involve the liquefaction of the gas for the purpose of investigating the properties of matter at the temperature of liquid helium, the lowest yet obtainable by any means. It is understood that a large grant from the appropriation for research of the University of Toronto is also available to extend the scope of the work and to permit experiments on the liquefaction of the gas to be carried out on a larger scale. The gas to be used for these experiments will, in large part eventually, be obtained from the Bow Island natural gas supplied to the city of Calgary. The results of this research, it is hoped, may point the way to the immediate utilization of the helium for purposes other than of inflation of lighter-than-air craft and thus encourage efforts to promote the conservation of the supply of helium which, large in amount in the Bow Island natural gas, is now being wasted at the rate of 1,000,000 cubic feet a month.

Professor J. C. McLennan received another grant also, of $1,000 for an investigation on the application of the Piezoelectric effect obtainable with crystals of tourmaline and quartz to the measurement of pressures generated by the exploding of

explosive compounds or mixtures. This research will have a bearing on the improvement of internal combustion engines and on the use of explosives generally.

A grant of $1,000 was given to Captain F. M. Dawson to enable him to undertake researches on the microscopic character of cement in relation to its hydration and its physical properties. This is a line of research which has not hitherto been undertaken. It is an attempt to apply the methods of examination that have been employed in the study of the minute structure of steel, alloys, etc., which have thrown a great deal of light on the effects of stress on metals in relation to microscopic structures.

Studies on the character of cement, whether microscopic or chemical or both, have to-day an importance that they did not have hitherto, simply because disintegration, through the action of alkaline soil waters, has become a serious menace to cement structures in the western provinces, where the loss is estimated in millions of dollars annually. Cement structures which in Eastern Canada will outlast many decades, in the West, when in contact with soils charged with alkali waters, last in the majority of cases for less than a decade, and this entails their replacement, not once, but several times in a generation. How this disintegration occurs is, as yet, not fully understood. The degree of hydration which occurs when the cement is first made may possibly be a very important element in the process of disintegration, as may also be the microscopical physical condition. Researches carried on under the Reclamation Service at Washington, with the co-operation of the Bureau of Standards, and by cement companies and engineering associations on the causation of the disintegration in cement structures in the Western States, where soils impregnated with alkali waters also prevail, have so far not thrown much light on the subject, and further investigation, it is understood, is to be undertaken to solve the question of the causation of the decay. The problem in Western Canada is, it would seem, much more important than it is in the Northwestern States, for there are few areas in the three Prairie Provinces in which the soil is free from alkaline infiltration, and in consequence the investigation of it must be undertaken on a scale and along lines that will ensure determinative results. This the Council proposes to do if the proper expert organization required can be constituted, and if, also, it can, out of its modest parliamentary appropriation, provide the necessary grant to meet the expenditures which will be thus incurred.

The investigation undertaken in 1918 by Professor W. P. Thompson, of the University of Saskatchewan, to produce a variety of wheat which will ripen earlier than the Marquis, the staple wheat of the western provinces, be resistant to rust and have good milling and baking qualities, was continued during the last year with the assistance of a grant of $2,500 made in the preceding fiscal year. A large portion of the work for 1919 was concerned in the breeding of rust-resisting varieties of wheat of commercial value, and it was found that varieties of wheat cultivated in a district and found to be immune to the rusts prevalent there, when grown in another district may not be resistant to the rusts of that locality. It has further been demonstrated that when a single wheat plant is inoculated with the rusts from different sources it is susceptible in a greater or less degree to some of these, while it usually is more or less resistant to the rest. This has made it clear that there are strains of rust which differ in their virulence, just as there are differences in strains of a bacterium which is pathogenic to the human or animal organism as revealed by the virulence or mildness of the attacks of the individual cultures. Whether, however, virulent strains of rust may, like virulent pathogenic forms of bacteria, develop from non-virulent ones, is as yet not definitely demonstrated.

Professor Thompson and his associates have produced a number of hybrids which have proved resistant to the rust strains investigated up to the present, but, judging by past experience, they do not expect them to prove resistant to strains not yet studied. This makes it necessary, before any decisively valuable results may be

obtained in the production of commercial rust-resistant hybrids, that there should be a thorough investigation to determine the total number and characters of the rust strains of all the districts in the western provinces and to ascertain whether new ones are continually originating and if so under what conditions. The attempts to produce new varieties of wheat by hybridization must, therefore, to be successful, wait till such an investigation is completed.

The completion of this preliminary work will, because of its magnitude, entail a larger programme than that hitherto attempted. Professor Thompson alone bravely began this work three years ago, but it must now, it would appear, be undertaken by an organization of biologists to each of whom should fall a special part of the work in order that the result hoped for may be achieved in a few years. It is a task that must be accomplished, for otherwise rust will be an abiding menace to the cultivation of wheat in the West, on which it takes a toll that is measured in millions of dollars annually. It is hard to conceive of a type of fatalism that will accept this menace perpetually, and efforts should be made to lift it now, for human ingenuity, based on the results that research on this line may furnish, should just as readily in this generation as in any later one, devise measures which will, if not abolish wholly the toll, reduce it to a scale that will greatly decrease its importance to wheat growing in Western Canada.

5. *Studentships, Fellowships and Bursaries.*—The Bursaries, Studentships and Fellowships awarded by the Council for 1919-20 were six, nineteen and seven respectively. Before the beginning of the academic session three of those awarded Bursaries, four of those awarded Studentships and two of those awarded Fellowships had resigned them. Two of the Fellowships, including the Ramsay Memorial Fellowship, are held in England (Cambridge and Manchester), while the other students are engaged in research in Canadian Universities (McGill, Toronto, Queen's, McMaster, Western, Saskatchewan, and British Columbia).

In order to provide for the training of a larger number of researchers for the immediate future and thus to meet in some measure the demand, which even now is developing, for capable researchers whom the progressive industries require, the Council decided to award twenty-five Studentships and ten Fellowships for 1920-21. These and the Bursaries, ten in number, at present established, will enable the Council to increase the number of students in training for a career in research from twenty-six to forty-five. This, it is believed will be sufficient to meet all the qualified applications for such assistance, but, it must be confessed, a very much larger number of such aids to students in training for research must be provided in the following year. How urgent this matter is, is indicated in another section of this Report, hut it may be pointed out here that if the National Research Institute, the foundation of which has been urged by the Council, should next year be an accomplished fact, the constitution of its staff would render the demand for highly qualified scientific research men of Canadian origin specially urgent. Indeed, one of the most serious difficulties the governing body of this Institute would have to face for at least a decade would be that of obtaining in Canada a sufficient number of highly trained researchers to fill the more technical positions on its staff. It is, however, not in Canada alone that this scarcity is felt. Complaint has been voiced both in the United States and England that research men of the right type are all too few, but the scarcity of such in Canada is greater than in those countries. The supply can be increased to meet the demand only by the provision of a larger number of Bursaries, Studentships and Fellowships for highly trained potential researchers during the next few years. There is no other way by which the need of Canada in this respect can be met. It is necessary to emphasize this, for there is a general belief, current even amongst those who ought to know, that there are enough scientific men of the research type to fill all the positions which call for such. This belief is in part due to the supposition that a

graduate in a special course of science of a university is thereby qualified to undertake research in some line in the science in which he specialized in his undergraduate course.

Two, three and four decades ago it was possible for such a student if he exemplified the type of mind and had the initiative required to undertake research and become a successful investigator, but the research of the last forty years has so greatly increased scientific knowledge that the science taught in the most highly specialized undergraduate course is but an elementary introduction to what is now comprehended under the term, even in a single department of it. A much more advanced knowledge is, consequently, necessary to research in any one field of science and to obtain it the student must prolong his studies into postgraduate years and at the same time undergo a training in the methods of research which is absolutely essential to him if he is to prove a success subsequently as a researcher. Two, three, and it may be even four years, after graduation, may thus be necessary and because of the expense involved few students are in a position to undergo unaided this training. The Bursaries, Studentships and Fellowships will permit those whose means are limited and who are of the type required, to prepare for a career of distinction in scientific research.

6. *Patents for Results Obtained in Assisted Researches.*—A majority of the researches to meet the expenses of which the Council has made grants of money involve industrial problems the solution of which may give results of practical application in industry and, therefore, in some cases at least, commercially valuable. Some of the researches already completed have given results of this character and, in connection therewith, the question arose as to the right of each researcher to take out a patent or patents for the discoveries he had made on the new process which his work had brought forward.

In determining the answer to the question a number of factors had to be taken into account. There is first of all precedent. The Imperial Department of Scientific and Industrial Research, to which the British Research Council serves as an advisory body, has decided that no worker under the Department may patent a discovery except with the leave of the Committee of the Council and where leave is given the patent is taken in the joint name of the inventor and the Imperial Trust for the Encouragement of Scientific and Industrial Research. The Department further reserves to itself complete discretion in the administration of the patent rights after consultation with the inventor and when a worker, engaged in a research under a Committee or Board of the Department, or in receipt of a grant from the Department, desires to take a patent he must do so in conjunction with the Imperial Trust, but in these cases the Trust reserves the right to refuse to be a party to the patent.

There are also the conditions on which the Research Council makes grants for research. These are not given to compensate the worker for the time or energy he may expend in the research but to pay for the material or apparatus he requires and the salaries of the assistants he may engage. His time and energy are given gratis and therefore he receives, so far as the research is concerned, no part of the grant. The investigation may be a tedious one and the supervision of it may require a very high degree of expert knowledge as well as capacity to lead the investigation to successful conclusions but the results, though of value, as scientific achievements may not be of practical application and accordingly his only reward is the consciousness that he has added something of value to the scientific record and to that extent enhanced his own reputation as a researcher. If, however, the results may be of commercial application, to whom do they belong? Not by any means wholly to the organization which makes the grant to defray the expenses of the investigation, for the grant may be much less than the equivalent of the energy and time which the researcher has expended in the work. Further the Council or the Patent Office should the right to take patents for the results be accorded either, is not in a position to develop the use of patents. This development can only be effected through publicity, through the inventor getting into touch with the industrial firms which can profitably use the processes patented and demonstrating

to their satisfaction that these are, if utilized, likely to prove of great advantage in reducing the costs of production or in increasing the output.

To refuse to have a process or invention patented is, except in a few cases, equivalent to consigning it to neglect. An invention that is unpatented, of course, may be used by any manufacturing firm but as the utilization of a process may and very often does involve the installation of new machinery or additions to the plant which may have to be altered as experience determines in order that the firm may profit from the application of the process, it is unwilling to make this venture as the results will be known to competing firms which are, therefore, in a position to avoid such mistakes and thus undertake the application of the process without any handicap. This serves as a deterrent to enterprise in this line. If, on the other hand, a possibly valuable process is patented the patentee may induce a firm to utilize it because, if it is eventually found to be successful it will not be handicapped by competition with other firms which have ventured nothing in the development of the invention. To provide, therefore, for the successful development of an invention or a new process in the industrial line it is necessary that it should be patented and that the patents should be held by some one who can promote its application in industry.

These considerations were all given due weight by the Research Council and, in consequence, it formulated the rule that when an assisted research results in the discovery of new processes, or in the development of inventions of industrial application, the investigator shall, under conditions to be determined in each case, be granted the right to take patents on the same after the Council has given its approval. The discoverer or inventor may thus reap the whole or a portion of the benefit from the results of the research, the extent to which he participates in this benefit being determined by the part that the grant in aid of the research played in bringing it to a successful conclusion or by the character of the results obtained which may be of limited application.

It will be noted that this principle is not quite in line with that laid down by the Council* in the case of inventions or processes discovered by technologists in the Government service. In the latter case it was recommended that the inventors or discoverers should be allowed at least half interest in each patent taken for Canada, the remainder of the interest to be held by the Government, while they should be allowed to patent their discoveries abroad in their own names. The reason, however, for the difference is that the salary of the technologist in the Government Service is met out of the Civil Service while the worker in charge of a research assisted by a grant given by the Research Council, who is not in the service of the Government, does not personally receive any portion of the grant, which must be spent only in meeting the cost of the material or apparatus used or in paying for the service of his assistants in the investigation. The two classes of researches are on a different footing and this dictates a difference in the rights which may be accorded either in the matter of patents.

In thus deciding concerning the rights in regard to patents of a private worker who has been given a grant to meet the expenses of his investigation, the Council reserves to itself the power to revise its position on the subject in any particular case in which special conditions obtain or in which the public interest predominates.

If a National Research Institute for Canada is founded in the very near future, according to the recommendations of the Research Council, it is contemplated that different regulations will be framed dealing with the discoveries and inventions of commercial value which may result from the researches of the members of the technical and scientific staff of the Institute.

7. *Industrial Alcohol.*—In the report of the Administrative Chairman for 1918-19, the question of removing the handicap on the production of industrial alcohol or "denatured" alcohol which the Inland Revenue Act at present imposes on it was discussed at considerable length and it was urged that the Act should be amended

*See Administrative Chairman's Report for the year 1918-19, p. 16.

so as to make the production of industrial alcohol as free from restrictions as it is in Great Britain and the United States. According to the provisions of the Act, alcohol can be denatured for industrial or other purposes only in Ottawa. Methylated spirits for consumption in British Columbia must at present, therefore, be conveyed to that province from Ottawa, a distance of two thousand five hundred miles, at a charge for transportation which, unless borne by the Inland Revenue Department, adds seriously to the price at which the consumer obtains it, while there is at least one distillery in that province which could, under amended regulations, provide all the industrial alcohol required there. The handicap which the consumers experience in the other provinces are only less serious because the distances of these from Ottawa are less than in the case of British Columbia but the effect is the same, that is, it tends to limit the use of denatured alcohol except in a few industrial lines in which, though the cost counts, it is indispensable for manufacturing purposes. This effect of the Act was of course not intended because its provisions are a survival of the times when Canada consisted of only five provinces and when also the industries, which used denatured alcohol, were very few in number and with a limited output. The misfortune was that the Act was not modernized at least soon after Congress had freed the manufacture of industrial alcohol in the United States from the legislative restrictions under which it operated till 1907.

What the removal of these restrictions on the production of denatured alcohol in Canada would mean may be gathered from the results of their removal on the production in the United States. Before the Act of 1906, which permits denaturing of alcohol at any distillery under conditions easily observed, the quantity of denatured alcohol used anually did not exceed 1,500,000 proof wine gallons, but after 1907 the consumption of it rapidly increased and reached 16,953,353 proof gallons in 1918 and 90,644,722 proof gallons in 1918, while the total amount of denatured alcohol made in Canada in 1917 was only 252,000 proof gallons. If the quantity consumed in Canada were in proportion to population it would amount to 6,000,000 proof imperial gallons.

Denatured alcohol is all important in a large number of lines of industry. This may be gathered from the enormously enhanced consumption of it in the United States since 1906 and from the annual consumption in Germany of more than 200,000,000 proof imperial gallons in the year ending August 31, 1904. Further, its use either alone or when mixed with benzol and xyol, as a motor fuel is increasing, and it is confidently predicted in certain quarters that it will be the sole motor fuel in two or three decades from now, that is when the oil supply of the United States will, it is claimed, be completely exhausted.* The high price of petrol in Great Britain even to-day makes it necessary to prepare to resort to alcohol as a substitute. The development in Canada therefore of cheap denatured alcohol not only for power purposes in the immediate future but also at present for use in the industries to the success of which it is vitally necessary, makes it imperative that the restrictions which hamper its production in Canada should be wholly removed.

Through representations on the subject made by the Research Council, the Canadian Branch of the Society of Chemical Industry, the Canadian Institute of Chemistry and the Canadian Manufacturers' Association, the Department of Inland Revenue, in May of 1919, took steps to amend the Act dealing with the production of industrial alcohol in Canada and towards the close of April, 1919, a Bill (No. 76) entitled "An Act to Amend the Inland Revenue Act" was introduced into Parliament which, with some alterations, might have passed but it included amendments dealing with subjects of Inland Revenue taxation other than alcohol and difficulties in the adjustment of the taxation of one product, acetic acid (including vinegar), delayed parliamentary action on the Bill till the last few days of the session when

*The Unmined Supply of Petroleum in the United States. By David White, Chief Geologist U.S. Geological Survey. Paper presented at the annual meeting, February 4-6, 1919, of the Society of Automotive Engineers.

it was crowded from the programme of agenda. This made it necessary for the various organizations concerned in the production of cheap alcohol for manufacturing purposes in Canada to review once more the situation and to endeavour to assist the Department of Inland Revenue in promoting legislation which would remove all the restrictions at present imposed on the use in Canada of alcohol for industrial purposes. The matter was again remitted to the Committee of the Council dealing with industrial alcohol which in February last presented a draft Bill to the Hon. Martin Burrell, Minister of Customs and Inland Revenue, embodying all the amendments in the Act which, in its opinion, would place the production of industrial alcohol on as favourable a basis in Canada as in the United States and more especially in Great Britain. A copy of this draft Bill is given in Appendix K. It is expected that the majority of the changes in the Act which the draft includes will be incorporated in the Bill on the subject of industrial alcohol which the Minister, it is understood, will introduce at an early date in the House of Commons.

The legislation desired is urgently necessary. The Department of Inland Revenue sells the denatured alcohol it prepares at 95 cents a gallon, but it cannot supply enough of it, and in consequence the price of methylated spirits on the market is $3.50 per imperial gallon, by the barrel, while the current market price of methylated spirits in the United States is $1.25 per imperial gallon.* Not a few industrial firms using methylated spirits on a large scale find it impossible to maintain on hand an adequate supply. If the manufacture of industrial alcohol were relieved of the present restrictions the distilleries of Canada would be readily able to supply the market in Canada with denatured alcohol as their capacity for production is about 8,000,000 proof gallons per annum at least. If in a few years this supply were not sufficient for consumption it would encourage the utilization of the sugar of the sulphite liquors of the pulp mills of Canada which could be made to yield probably an additional supply of as much as 10,000,000 proof gallons.

The Research Council in the draft Bill referred to suggested a provision for duty-free alcohol for use in certain existing or new industries in which its use is indispensable. The clause in which this is dealt with reads as follows:—

> "Alcohol without any denaturant shall be sold or delivered, free of excise duty, under such conditions and in quantities, as the minister by regulation may prescribe to specially licensed manufacturers of such products in the preparation of which pure alcohol is essential as an agent solvent or precipitant but in which the finished product contains no alcohol."

This clause is in effect but a reproduction in other words of section 8 of the Imperial Finance Act, 1902, which reads as follows:—

> 1. Where, in the case of any art or manufacture carried on by any person in which the use of spirits is required, it shall be proved to the satisfaction of the Commissioners of Inland Revenue that the use of methylated spirits is unsuitable or detrimental, they may, if they think fit, authorize that person to receive spirits without payment of duty for use in the art or manufacture upon giving security to their satisfaction that he will use the spirits in the art or manufacture, and for no other purpose, and the spirits so used shall be exempt from duty:
>
> Provided that foreign spirits may not be so received or used until the difference between the duty of customs chargeable thereon and the duty of excise chargeable on British spirits has been paid.
>
> 2. The authority shall only be granted subject to a compliance with such regulations as the Commissioners may require the applicant to observe for the security of the revenue, and upon condition that he will, to the satisfaction of the Commissioners if so required by them, render the spirits unpotable before and during use, and will from time to time pay any expenses that may be incurred in placing an officer in charge of his premises.
>
> 3. If any person so authorized shall not comply with any regulation which he is required to observe, he shall, in addition to any other fine or liability, incur a fine of fifty pounds.

*The price of methylated spirit in the American market was one year ago 60-62 cents per gallon (imperial measure). The price in February, 1920, was less than 85 cents per gallon. The increase in price to $1.25 is no doubt due to the dwindling of the stock of alcohol in bond, through operation of the Volstead Act.

The importance of allowing duty-free pure ethyl alcohol to be used for certain industrial purposes may be gathered from the fact that large quantities of synthetic compounds and also of alkaloids are used in Canada annually, all of which has to be imported because tax-free pure ethyl alcohol is necessary in their production. Further certain of the vitamines,* those compounds the absence of which from human diet causes scurvy, rickets, beri-beri, marasmus, osteomalacia, etc., are soluble in a pure form from fresh fruits, vegetables, animal and vegetable fats, etc., only by the aid of pure alcohol. None of the denatured alcohols can be used because the denaturant is prone to absorption on the final product and would make it objectionable and with the great majority of denaturants used, toxic. Some of the vitamines have been prepared in a concentrated form for research purposes in scientific laboratories but only with the aid of pure ethyl alcohol, of course duty-free. There will arise very shortly an ever increasing demand for them, in considerable quantities not only for treatment of deficiency diseases of childhood but also for admixture with foods for ordinary consumption and no artificial difficulties should be imposed on their production in Canada.

It is also to be noted that the separation of fat from fish waste is at present effected by crudely empirical methods and the product is useful only in the manufacture of soap. If this fat could be extracted with pure alcohol on a large scale the fat might ultimately be obtained in a form suitable like pure and tasteless codliver oil for human consumption and as such it would be more valuable. If ethyl alcohol could have been used free from excise duty it would long ago have been extensively used in the extraction of fat from a number of sources for use as food. Extraction with denatured alcohol leaves the denaturant in the fat from which it is difficult to remove, and the product is, therefore, impossible as a food.

There are other lines in which the use of pure ethyl alcohol would be of great service industrially and in which denatured alcohol could not be employed. The examples given are sufficient to indicate that provision must be made in Canada for the use of duty-free alcohol in certain lines which because of their fundamental importance to nutrition cannot be ignored.

8. *Conservation of Natural Gas.*—The Council has given attention to the question of the conservation of the supply of natural gas in Canada. It is a subject in which Canada is not alone interested.

In the United States there has been a criminal wastefulness of the supply, which the public has treated as if it were inexhaustible. Exhaustion of the supply is now threatening in a number of American cities, for example, Cleveland, Toledo, etc., and, as a result of the awakening of opinion, which this has produced, a public conference of governors, public utility commissioners, state geologists, home economic experts, natural gas companies, owners and officials, and appliance manufacturers was called by the Secretary of the Interior, Mr. Lane, to meet under the auspices of the Bureau of Mines at the Interior Department Building, Washington, on January 15, to discuss the waste and determine how to conserve to the utmost the supply.

*The knowledge of these exceedingly important constituents of diet was obtained in researches carried on at first by British Biochemists from 1911-1916 and later chiefly by American Biochemists. The war prevented the dissemination of this knowledge through Germany and Austria and this accounts in a very large measure for the appalling prevalence of rickets amongst the children in Vienna and certain other cities of the Central Empires.

As a result of the work of experts of the Bureau of Mines, it has been determined that in the consumption of natural gas an efficiency only of about 13 per cent from a gas cook stove, 25 per cent from a house heating furnace and 10 per cent from a hot water heater was obtained although in good practice the efficiency could be readily trebled, in other words, that one-third of the natural gas consumed daily would be sufficient for all the present purposes and the supply, therefore, could be made to last three times as long.

This meeting took place on the date indicated and a committee of ten was appointed to consider the wastes now going on in natural gas, and the relation between the natural gas companies and the consuming public. The Committee will formulate a programme looking forward to the application of those engineering principles which, it is known, will minimize the waste of natural gas now taking place and prolong the supply of gas to the consumer

The gas supply in southern Ontario is rapidly diminishing and within a generation it will be but a memory. The supply in Alberta is still voluminous but it is wastefully used. At Medcine Hat it is consumed as if it were inexhaustible, but the reported increasing occurrence in it of the hydrocarbons heavier than methane indicate that the exhaustion of the supply there is not far distant. The exhaustion of the supply of the Bow Island gas is predicted by the fact that the pressure is lessening. Consideration of the conservation of this supply is a question of urgent importance. Economy in the use of the gas at Medicine Hat means that the prolongation of certain favourable conditions for industrial enterprise there will be maintained correspondingly. The conservation of the supply of natural gas in Calgary means cheaper domestic lighting and heating for cooking purposes.

This question has been brought to the attention of the Research Council by Mr. Wm. Pearce, who has long been urging measures looking to economy in the use of the gas.

It is a matter that must be dealt with locally at Medicine Hat and at Calgary, but the Research Council would like to emphasize the necessity for immediate action on this subject by those concerned. This generation will not be justified in the verdict of the next, if the present wastefulness is not greatly curtailed, and the Research Council thinks it is incumbent upon the authorities of the cities of Medicine Hat and Calgary, and also upon the Canadian Pacific Railway Company, to consider the situation and how to evolve a system that will provide against this wastefulness.

There should be a conference of all concerned like that held at Washington on January 15 last, to consider all the aspects of the questions and take measures accordingly. It may be pointed out that the greater proportion of the gas-bearing lands of the three Prairie Provinces are privately owned. Further, the positon of the grantees of gas lands in the other provinces is that of a contract. There are few gas wells in the Dominion under public control, and, in view of this, it may be necessary to make provision for such control in all future leases, and, especially, in those for northern Alberta where the next largest supply of natural gas it is expected, will be tapped.

9. *The Conservation of the Supply of Helium in Canada.*—Helium is a gas of peculiar properties. It is extremely inert, does not combine with any other element and its weight is, with the exception of hydrogen, the lightest of all the gases. Its inertness and other physical properties would seem to indicate that it is extremely serviceable for electric bulbs, as it does not promote alterations of any sort in the films of the same. Its inertness also and its lifting power qualify it for filling balloons, the motors of which may be attached inside of the balloon or dirigible envelope, with none of the risk involved in the use of hydrogen for inflation of these lighter-than-air craft. It is likely to be used in aviation, because of its physical properties, and in electrical appliances, bulbs, etc. It would probably have been used very extensively in aviation, for observation balloons and offensive dirigibles, had the war been prolonged a year or two more. It is the subject of investigation, also, in relation to

refrigeration and the production of very low temperatures, a line of work in which the development must surpass, it is believed, ordinary immediate expectations.

Canada is the only portion of the British Empire which furnishes this gas. It is, of course, abundant in the supply of gas from certain of the gas wells in Kansas, Oklahoma and Texas, and in certain of the gas wells of southern Ontario and in the gas well at Bow Island, Alberta. The supply of natural gas at Bow Island contains 0·3 per cent of helium, and, on this basis, the amount of helium lost through the use of natural gas in Calgary amounts to about 12,000,000 cubic feet a year, which, computed at 10 cents a cubic foot, a low valuation, would make the value of the helium so lost amount to $1,200,000 a year. The quantity of helium in the gas of the gas wells of southern Ontario is much less, probably not more than one-tenth, of the quantity of the Bow Island supply.

The possibly approaching exhaustion of the gas wells in Ontario, and especially of the Bow Island gas supply for the city of Calgary makes it imperative that measures should be taken to conserve the helium in this supply and also in the supply from other gas wells which may be opened up. Once exhausted, there is no renewal of the supply of helium, unless some important discovery, involving extensive mutation or decomposition of the atoms of a chemical element, may make it available. It is, therefore, urgent that what Canada has of this supply should be conserved to the utmost.

How this can be done with the Bow Island supply remains to be seen, but the control of this gas has passed out of the hands of the Department of the Interior, as the lease given the company concerned is all-comprehensive on this point. There is a possibility that the company may find it profitable to assign the extraction of the helium to corporations which may export it, and for a time there was a suggestion that an American company had been organized with a view of acquiring the right of extraction of the helium from the Bow Island gas supply.

As the Federal Government of the United States has prohibited the export of helium from the United States, it is obvious that it is in the interest of Canada to preserve for its own use any helium that it may have and that efforts should be made to prevent its export.

The Council carefully considered this subject and recommended that in all future leases issued by the Department of the Interior it should be provided that all rights to helium in the gas should be reserved so as to enable the Government to extract this gas from such supplies. The resolution which the Council passed on the subject is as follows:—

> From the surveys which have been made of the natural gas supplies of the British Empire it would appear that the natural gases obtainable from the wells in Southern Alberta and from those situated along the Grand River valley and in the Niagara peninsula of Western Ontario, are the only ones which contain helium in amounts which at present would justify the expense of extraction.
>
> The amount of helium obtainable from the wells at present in operation in Southern Alberta would appear to be 1,000,000 cubic feet a month, while the amount obtainable from the wells located in Western Ontario would appear to be about one-tenth of that amount.
>
> In the war it was shown that had helium been available for observation balloons and other lighter-than-air craft, our effectiveness as a military nation would have been very much greater. The war would probably have been shortened and many lives would have been saved. It would seem desirable, therefore to conserve all supplies of helium within the Empire for future uses and emergencies. It is understood that this is the view taken by the Governmental authorities of the United States which is reported to have bought up from the natural gas companies the right to extract helium gas from all the gas produced.

It would seem desirable therefore that the Government of Canada should (possibly after consultation with the Government of Great Britain and Ireland) take the necessary steps to reserve to itself, in all future gas production leases granted by the Government, all rights to the helium in the gas, and that consideration should be given to the question of securing the right to extract helium from those supplies of natural gases in Canada for which leases have already been granted.

A copy of this resolution was communicated to the Minister of the Interior, who informed the Council that "all petroleum and natural gas leases issued on and after the 2nd day of March, 1914, contain the following provision:—

"The Minister may at any time assume absolute possession and control of any location acquired under the provisions of these regulations, if in the opinion of the Government of Canada such action is considered necessary or advisable, together with all buildings, works, machinery and plant upon the location, or used in connection with the operation thereof, and he may cause the same to be operated and may retain the whole or any part of the output, in which event compensation shall be paid to the lessee for any loss or damage sustained by him by reason of the exercise of the powers conferred by this provision of the regulations, the amount of the compensation, in case of dispute, to be fixed by a judge of the Exchequer Court of Canada, provided that the compensation in any case shall not exceed the profit which the lessee would have earned in the working of the location and the disposal of the produce thereof, had possession and control of the location and of the building, works, machinery and plant not been assumed."

Under this provision, it was held that the Government might assume absolute possession of nearly all the petroleum and natural gas leases issued in Saskatchewan and Alberta and might retain the whole or any part of the output, by way of compensation. This clause, thus rightly interpreted, could no doubt enable the Government to make an arrangement with the lessees, whereby it might secure the right to extract the helium from the flow of natural gas.

This clause in the leases issued since March 2, 1914, however, in the opinion of the Deputy Minister of Justice, can only be made effective, so far as the extraction of helium is concerned, when the Government assumes the possession and control of the location as provided in section 41 of the regulations under which the leases were issued.

In consequence of this interpretation of the clause in the leases referred to, the Department of the Interior has prepared a clause for insertion in all future petroleum and natural gas leases, reserving to the Crown the right to the helium in such gas as may be discovered, together with full power to install machinery and extract such product from the gas.

The supply of the Bow Island gas is diminishing as the pressure under which it flows into the city mains lessens. It is possible that a well in the same district, sunk at the centre of the field but not to the same depth, may renew the supply, but eventually this supply must diminish to a vanishing point.

It is not certain, however, that in such a supply there will be much helium, because though it is lighter than the natural gas itself, and diffuses readily the conditions favouring diffusion may not obtain over the whole field and, possibly, the whole supply is in the gas already tapped at Bow Island. It is, therefore, a matter of wisdom to utilize, as far as possible, the present supply. It is unthinkably uneconomical to allow it to be wasted as it is at present, and measures should be taken to extract all the helium from the gas before it is consumed in Calgary.

How this conservation may be effected is a matter for consideration on the part of the company in control of the Bow Island gas supply, and also by the Dominion,

which ought not to look with indifference on the exhaustion of this, amongst the rarest of all the gases, and which may be in the future of exceedingly great industrial value.

It may he noted that extensive provision is being made by the Federal Government of the United States for the conservation of the helium in the gas supply of Texas. The Army and Navy Departments arranged jointly to allot $5,000,000 for this purpose, including the construction of a new pipe line and additional units at the Lynde plant installed at Fort Worth, Texas, for the extraction of helium. The additional plants under construction there will provide for the extraction of 50,000 cubic feet of helium a day.

It may be pointed out that, if a helium extracting plant were installed on the main pipe line supplying Calgary, the helium could be removed and the natural gas turned into the city mains from the plant under the same pressure as the latter received it, and there would he no inconvenience experienced by the consumers as a result of this extraction.

If the ownership of the natural resources of Manitoba, Saskatchewan and Alberta is given over to the Governments of these provinces, it may be necessary for them to make provision for the conservation of the helium supply, wherever issuing with the natural gas.

The exportation of helium from the United States is prohibited, without special permit, in the draft of a Bill which has been submitted to Congress in February, 1920, by the Secretary of the Navy. The President is authorized, by the Bill, to prescribe appropriate rules and regulations governing the exportation of helium. Exportation without such a permit is to be punishable by imprisonment for not more than five years and not less than one year, or by a fine of not less than $5,000 or by both. The Secretary of the Navy, in recommending the adoption of the measure, wrote to the Chairman of the Inter-State and Foreign Commerce Committee, as follows:—

"The sources of supply of helium in the United States are not numerous and the quantity obtainable is very much limited. This gas is non-inflammable and is, consequently, of inestimable value for balloons of all kinds, and, especially, for those of the dirigible types, that the Navy Department is endeavouring, under authorization by Congress, to develop and bring to a state of the greatest efficiency. It is manifest, therefore, that the public interests imperatively require conservation of the supply of this gas, as the demand for it abroad is insistent and great enough to consume, in all probability, within a short time the available supply in this country."

10. *Associate Committee on the Problems Affecting the Fox-breeding Industry.*—In April, 1919, the Council was requested, by a number of those engaged in the fox-breeding industry in Prince Edward Island, to investigate some of the difficulties which the fox-breeders of the island encountered in the breeding and rearing of foxes. These foxes are of the "black" or "silver" kind, and their pelts are exceedingly valuable, in some cases a pelt selling for as much as $1,000, while others are sold for prices varying according to their variation from the standard "black" or "silver" kind.

The difficulties, the breeders felt from their experience, arose from diseases, parasites, malnutrition, early mortality, etc. As the value of the pelts sold annually in Prince Edward Island, it was estimated, amounts to about $1,000,000, the Council decided that the subject deserved careful attention, and it deputed Dr. Andrew Hunter, Professor of Biochemistry in the University of Toronto, to proceed to Prince Edward Island to examine the conditions which affected unfavourably the fox-breeding industry.

Professor Hunter spent some six weeks visiting all the ranches accessible, and finally presented a report, the substance of which was subsequently published as a

bulletin.* This report, which has found a circulation, not only in Prince Edward Island, but in Nova Scotia, New Brunswick, Manitoba and, through a French edition, in Quebec, points out that from 40 to 60 per cent of the foxes born never reach maturity, and though the average number at birth is not less than three and is often from five to seven, those raised to adult age do not exceed 1.25 per pair. The mortality is, therefore, very great. In ranches where great care is taken, though determined on wholly empiric lines, the yield is over 2·5 and, in some cases, it exceeds 4. The report points out, further, that it would be hard to say what might be the practical limit of improvement, but, if the actual yield were now 1·5, and the generally attainable set not higher than 3, it would not seem unreasonable to hope that the revenue from the industry might, by scientific management, be at least doubled, that is, the returns instead of being $1,000,000 would be $2,000,000 a year.

Amongst the factors causing this high mortality were infectious diseases, parasites, food poisoning and imperfect nutrition. Infectious diseases and parasites may be provided against by care on the part of those concerned. At present a very considerable amount of lore is available on these two subjects and, further, the Health of Animals Branch of the Department of Agriculture has been giving attention to this subject, so far as Prince Edward Island is concerned.

Food poisoning, however, and imperfect nutrition are at present more or less obscure subjects. The diet administered is not constituted according to scientific principles and, further, the composition of it varies from ranch to ranch. Food poisoning, it would appear, rarely occurs. In some cases the horse flesh used, it is suspected, was tainted, and it has been suggested that the flesh came from animals that had been dosed with arsenic for therapeutic reasons and the flesh, therefore, impregnated with arsenic, was more or less toxic to the foxes.

The diet of the foxes is not, as already stated, constituted on scientific lines. Even where the diet, as in certain ranches, gives favourable results, it is based on purely empiric experience, but it does not necessarily follow that, where it appears to be successful, it is as valuable as a diet based on scientific principles. The proper diet of the fox is not known. There has been no investigation of its metabolism, such as has been carried out in the case of the dog and certain other domestic animals. In consequence, one diet is regarded as good as another until it proves to be impractical or gives untoward results, and it is thus that the empiric diet has been evolved.

Dr. Hunter recommended that an investigation of the metabolism of the fox should be undertaken, in order that its diet should be placed on an unassailable basis. This recommendation the Council accepted and it appointed a Committee to superintend an investigation on the nutrition of the fox, of which committee Dr. Hunter was appointed Chairman. This committee was instructed to work in co-operation with the Health of Animals Branch of the Department of Agriculture.

The committee has, in co-operation with the Department, decided to conduct the investigation on the nutrition of the fox at the Biological Research Laboratory at Hull, where the Department has installed quarters for the investigation and also pens and kennels for six pairs of foxes. A grant of money has been made to meet the expenses of this investigation. An investigator, a biochemist, has been appointed to carry on the investigation on the animals, and it is hoped within two years to obtain the data which will enable the fox-ranchers to formulate a diet that will be physiologically sound, and, if carried out, will lower the mortality which at present is believed largely due to mal-nutrition.

The character of the committee itself, consisting of physiologists, biochemists, veterinarians, etc., promises that the investigation will certainly be of a character that will result in data which will dispose of mal-nutrition of the fox as an untoward factor in fox-breeding.

*Bulletin No. 8, "Some Problems of the Fox-Raising Industry," published by the Honorary Advisory Council for Scientific Research, 1919.

11. *The Manufacture and Use of Nitrogenous Fertilizers in Canada.*—In 1917 the Research Council had its attention called, by the Dominion Food Controller, to the necessity of increased crop production in Canada, and, associated with this question, was the increased use of nitrogenous fertilizers.

An inquiry at the time showed that the production of ammonium sulphate, resulting from the coke production and in the various gas plants throughout the Dominion, was about 14,000 tons, which was almost wholly exported to the United States and to the West Indies. There was, therefore, very little used in agriculture in Canada. In some provinces, in the West particularly, the use of such fertilizers was not considered necessary because the soils were virgin, and this led to a waste of the ammonia of some of the gas plants, notably that at Winnipeg, which until recently turned the ammonia liquor resulting from the manufacture of gas from coal into the city drains.

The quantity of ammonium sulphate now produced in Canada amounts to about 17,000 tons, which, with the exception, as in 1916, of a few hundred tons, is wholly exported. It is also to be noted that about 60,000 tons of calcium cyanamide, made at Niagara Falls, Ont., is, with the exception of a few tons, wholly exported. This fertilizer can under certain conditions replace ammonium sulphate in certain soils.

There are certain parts of Canada in which nitrogenous fertilizers are necessary, in order that the crop production may be kept up to the standard obtaining elsewhere. If more fertilizers were used, and particularly those of the nitrogenous kind, the crop production, in Ontario, for instance, would greatly exceed what it is now. The fact is that in certain agricultural sections of the Dominion there is an inclination to ignore, or refrain from, measures which will increase soil fertility and thus bring down the cost of crop production.

In the agricultural sections of Germany, where the land has been tilled for centuries, and which, to begin with, was of a poor character, the wheat production was raised to 31-33 bushels per acre, as compared with 22-25 in Ontario for the same time. The difference is due to the fact that the German farmer freely applied fertilizers to the soil, recognizing that such application rewarded him, ultimately, handsomely.

In certain portions of Canada the soil has been undergoing a process of exhaustion for two, and even three generations and little has been put back into it. In other words, it is "mined." This process is going on in the West to-day, and within ten to fifteen years the result will be shown, even under otherwise most favourable circumstances, in a greatly decreased yield of crops. If the recognition were general, that the application of fertilizers would result in greatly enhanced crop yields, the total amount of ammonium sulphate and of the cyanamide produced in Canada would be retained for use on the farm lands which have now suffered more or less of exhaustion in their nitrogen-holding constituents. If such extensive use of fertilizers were resorted to, it would entail the consumption of four or five times the quantity of ammonium sulphate and calcium cyanamide produced in Canada. The production of these would be readily quadrupled if the market for them in Canada were enlarged by their use in the sections of country where they are needed. The various gas works producing gas from coal distillation, which now do not utilize the resulting ammonia to form ammonium sulphate, could, by this enlarged market, be made to utilize, instead of wasting it, the ammonia of the liquor which is now thrown away.

Further, as a result of the work of the Lignite Utilization Board, in demonstrating the briquetting of the poorer lignites of Saskatchewan, there may develop a large number of plants erected for this purpose in Saskatchewan and Alberta. The ammonia liquor resulting would yield a very large amount of ammonium sulphate. An increase in the amount of cyanamide produced may be expected from the fact that a large part of the water-power of Canada is still undeveloped.

These facts make it evident that the increased production and use of fertilizers in Canada is a matter of national importance. Their use depends upon a system of education in the agricultural sections of the country on the value of fertilizers appropriately applied.

The Council, accordingly, has undertaken to call the attention of leading agriculturists and those concerned in the work of the various experimental stations through the Dominion to the importance of the use of fertilizers as a means of increasing the wealth of the country. It has issued a circular, calling attention to many of the facts here referred to, which suggests methods of co-operation between different organizations to educate the farmers as to the advisability of the increased use of fertilizers.

A copy of this circular is published as Appendix L.

It may be pointed out that since 1900 the food supply of the world, according to publicists dealing with the subject, has been steadily decreasing. At that time the supply of food was sufficient for six months ahead. In 1914 it was only sufficient for about three months ahead. It has been claimed that the food supply of 1919 was only about two months ahead, and, if the old wasteful methods of consumption were then employed it would not last six weeks. It has also been claimed that it will take twenty years for the food supply to reach what it was in 1900. In the meantime, conditions throughout the world may bring hardships approaching those of famine, and, in consequence, the production of food from the soil may be not only a duty to the State but also to humanity.

12. *Exploration and Survey of the Oil Shales of the Dominion.*—The Council had its attention called to the importance of this subject by the representative of an English firm of capitalists desirous of investing large sums of money in Canada, who had come to Canada in November, 1919, to report upon the possibilities of successful development in Canada of the oil shale industry and of the production of potash from any potash holding deposits.

After several weeks in Ottawa this representative reported to the Administrative Chairman that, although there were extensive deposits of oil shales in the Dominion, the character of these had not been fully determined, to justify the investment of capital in their development. In some cases the surveys are of a very indefinite character, and consequently, any attempts at undertaking their development might involve very considerable risk, possibly failure, unless secured against such by thoroughly ascertaining at the outset all the factors which would promote success.

Some of these deposits are more or less well-known, those, for example, in Pictou county, N.S., and in Albert county, N.B., but even in regard to these there is an indefiniteness as to their extent and the possibilities of their being successfully mined, which deters investment in them. About the other deposits, and especially those of the Pasquia Hills district of northeastern Saskatchewan, only the most general or superficial knowledge is available, as no systematic scientific surveys of them have been made.

The extent of the deposits in the Pasquia Hills district is probably very great, but the yield of oil and of ammonium sulphate which they may furnish has not been at all determined, although specimens obtained at different points from these regions gave, on analysis, indications of a high yield. These data are not sufficient, however, as the extent of the deposits of which the specimens analysed were samples was not determined. What is required is a knowledge, not only of the extent of the oil shales and their possible yield in oil and ammonium sulphate at any one place, but also the range and character of these deposits from point to point all over the areas where they are found.

If this information were available for all the deposits, it would assist greatly in the development of these oil shales before the world supply of oil from oil wells approaches exhaustion, which, so far as the United States is concerned, will occur within twenty years.* The approaching exhaustion of this supply of oil in the United States will compel the development of the extensive oil shale deposits in the Western States.

*According to an estimate made by Dr. White of the U.S. Geological Survey, the oil supply of the United States will be exhausted in about sixteen years.

The Council, in view of these considerations, passed the following resolution:—

> "That the Department of Mines be urged to undertake a comprehensive investigation of the oil shale resources of the Dominion, and particularly those of Western Canada, and that a report embodying the results of this investigation be published at as early a date as possible."

A copy of this resolution was placed before Sir George E. Foster, Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, and also before the Hon. Arthur Meighen, Minister of Mines.

The Department of Mines, it appears, accordingly arranged to make provision during 1920 for this survey, but, owing to the resignations from the staff of the Survey, and also from the Mines Branch, it felt itself unable to carry out this programme for the year, but it hopes that in the next year it will be in a position to undertake this survey on an extensive scale.

The Council believes that the oil shales of the Dominion may yet prove a source for a large supply of oil fuel and gasoline, and holds that the development of these shales should be systematically encouraged.

13. *The Formation of Associate Committees.*—The Council during the year appointed a number of Associate Committees to superintend special lines of research.

Amongst these is the Physics and Engineering Physics Committee, constituted to deal with all questions concerning researches in pure physics and also in physics on the engineering side. This committee is composed of the leading professors of physics in the universities of Canada and it also contains in its membership a number of others who are engineers with special attainments in physics.

An Associato Biological Committee was constituted of the leading biologists, physicists and biochemists in Canada, to encourage research on problems in marine biology and physiology.

An Associate Committee on Food Research was appointed to superintend researches on the newer food problems, including in that the constitution and functions of the vitamines, which are now known to be absolutely necessary in diet, the absence of which from diets cause what are known as deficiency diseases, amongst others, scurvy, rickets, beri-beri and possibly pellagra. The importance of these problems has been revealed by the war in Central Europe, where children reared on diets considered sufficient according to the knowledge current before 1913, have been the victims by thousands of rickets, marasmus, etc.

The significance of the problem may be gathered from the fact that it affects everywhere the diet of children and even of adults, and it is associated more or less closely with the question of milk as food. The importance of the problem is likely to be greatly enhanced in the near future, because the part that these vitamines play in the growth and in the well-being of the individual is to-day only partially indicated, and it is not unreasonable to suppose that questions of hygiene are profoundly associated with their action in the body.

The committee is composed of a number of biochemists whose work will be the investigation not only of these vitamines but also of any problem which concerns the nutrition of the human subject.

A Fuel Research Board was also appointed to deal with the standardization of coals throughout the Dominion. The necessity for this arose through representations made by the Hon. Mr. Stewart, Premier of Alberta, who had had under consideration the question of standardizing the coals of Alberta, because of the injury done to the coal trade of Alberta by the marketing in Winnipeg and other places of inferior coals, which had been represented as standard Albertan coals. This precipitation of inferior coal on the market led to a curtailment during the last year of the consumption of Albertan coal in Winnipeg and other places. It was claimed that, if the coals were standardized as to ash content, heat value and their use for domestic furnaces, the

consumers would buy according to the standard, and thus they might resort to Albertan coals of the better character and so obviate the necessity for the importation of coal, other than anthracite, from the United States.

This board is constituted of four representatives from the Prairie Provinces, including President Tory, of the University of Alberta, and one from Eastern Canada, and its work will for the present be carried on in association with the coal laboratory instituted at the University of Alberta. Its function will be to standardize the coals from the various mines of Alberta and publish the results of its work, to guide the market in the use of these coals.

An Associate Air Research Committee was appointed to initiate and superintend researches in problems connected with aviation. This committee, which is under the chairmanship of Professor A. S. Eve, F.R.S., head of the Department of Physics of McGill University, is working in close co-operation with the Air Board of the Government, representatives of which, with Col. O. M. Biggar, the Vice-Chairman of the Board, attend the meetings and take part in the work of the committee. With this committee are associated a number of experts in aeronautics who will give attention to problems which will be referred to them. In Appendix H is given an account of the activities of the committee to the end of March, 1920.

14. *Central Information Bureau.*—In the Report of the Arministrative Chairman for 1918-19, the subject of the establishment of a Central Information Bureau, to disseminate information regarding the natural resources of Canada for the purpose of promoting their development, was discussed and the establishment of such a Bureau was urged.

The subject had then arisen through a resolution adopted by the Associate Committee on Mining and Metallurgy at its meeting on March 5, 1919, which read, as follows:—

> Whereas, in the present critical period of industrial readjustment and expansion it seems most important that all information concerning national resources which has been so painstakingly gathered by Government Departments in Ottawa should be quickly and completely available to responsible inquirers planning to build up various industrial enterprises based on the exploitation of these resources, and
>
> Whereas, such information necessary for the development of a single enterprise often lies in the records of more than one of the Government Departments so that vexations and dangerous delays frequently occur in the collection of the necessary data for important projected developments.
>
> Resolved, by the Associate Committee on Mining and Metallurgy of the Advisory Council for Scientific and Industrial Research that it is highly necessary that a Central Information Bureau should be established by the Government in Ottawa wherein all the different Departments should co-operate to make readily available complete up-to-date information regarding all the natural resources of Canada except those relating strictly to agriculture.

There is, it may be stated once more, a large amount of information collected, not only in certain of the Government Departments, but also in the Scientific Bureaus of the various Provincial Governments, information which, if centralized and collated, would be of the greatest value in stimulating the development of these resources. At present the information can only be obtained by those desiring it, in a piecemeal manner and by correspondence which may at times be tedious and protracted, and when it is obtained there is still the suggestion that it is more incomplete than it should be, were the information systematically gathered by a bureau specially organized for this purpose. This is a serious handicap on the development of those natural resources.

There are organizations in Ottawa which aim at giving information regarding the natural resources, for example, the Natural Resources Intelligence Branch of the

Department of the Interior, the Mines Branch of the Department of Mines, and the Mines Department itself. These are, doubtless, in a position to give, on some subjects, a considerable amount of information in response to requests for it, but there is not co-operation between these organizations and the various Provincial Bureaus, except perhaps of a more or less uncertain character.

Further, the Natural Resources Intelligence Branch, as it is not directly connected with the exploration of these resources, has to gather this information by extraction from publications and, very largely, by correspondence, as it may be required in any particular case, and this necessitates delay in cases in which it may have a discouraging effect.

The Bureau that the Council proposes is one which would have all the information available anywhere up to date, regarding all the resources of Canada, and it could, therefore, supply reports to any inquirer on any subject within twenty-four hours after a request for information would reach it.

The Council, influenced by these considerations, adopted the following resolution at its meeting, held on December 12:—

> "That this Council is of opinion that a Central Bureau of Information should be constituted at Ottawa at an early date for the purpose of rendering promptly available, and of disseminating, all information which might facilitate the utilization of Canadian natural resources and the development of Canadian industry."

Copies of this resolution were forwarded to Sir George E. Foster, Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, and to the Hon. Arthur Meighen, Minister of the Interior and Minister of Mines.

It may be pointed out that when the natural resources of Manitoba, Saskatchewan and Alberta are given by the Dominion to these Provinces, there will be, more than ever, a need for such a Central Information Bureau. The exploration of these resources will then, very probably, be undertaken by these Provinces, and much less in the way of such work will be done through the Dominion Government departments, such as the Department of Mines.

In consequence, there will be less information available in Ottawa because of the decrease of activities in such exploration on the part of the Dominion Government. There will then have to be some organization, whose functions it will be to collect from all the Provincial Governments the information that their scientific staffs may acquire through exploration and observation.

The ability of the Dominion to bear its huge burden of debt will depend on the rate of increase, annually, in the next few years of the wealth developed from these resources, and, therefore, the Dominion is specially interested in assisting every agency and organization that aims at utilizing the natural resources. The Dominion, therefore, should constitute an efficient organization which will disseminate all information on these resources, that may assist in making them available for development.

In thus emphasizing the necessity for a Natural Resources Information Bureau, it may be pointed out that the Council does not pronounce upon the character of the organization itself or as to whether any of the present organizations should be taken as the nucleus of such a Bureau. It urges the formation of thia Bureau simply because it regards its constitution as a measure of immediate importance to the development of the natural resources of the Dominion.

15. *The Utilization of the Iron Ores of Canada.*—The utilization of the iron ores in Canada, to which reference is made in the Section on Assisted Researches, is one of the subjects to which the Council is giving careful consideration because of its national importance. A Committee of the Council, under the chairmanship of Mr. Lloyd Harris, appointed to report as to measures which should be taken to promote

the development of these deposits, as one of the results of its activity recently, formulated its position in a memorandum which was unanimously endorsed by the Council and subsequently submitted to the Sub-Committee of the Privy Council and to Sir Henry Drayton, Minister of Finance. This memorandum was as follows:—

> The question of the utilization of the native iron ores of Canada has at various times been before the Honorary Advisory Council and they have collected many data concerning these ores and have subsidized researches bearing on various phases of the question; but the importance of the matter is so great and the necessity for the development of a basic steel industry in Canada so pressing that the Honorary Advisory Council respectfully wishes to bring the matter before the Government in the hope that they may give consideration to the whole question.
>
> The Honorary Advisory Council would respectfully suggest the following as a line of procedure:—
>
> 1. The Advisory Council to support researches on the treatment of iron ores which appear promising.
>
> 2. The Department of Mines to collate and concentrate all available data relating to known iron ore deposits in Canada and to follow this by instituting immediately further surveys in Canada where favourable indications of iron deposits have been obtained.
>
> 3. The Government of Canada to consider the adoption of a policy such as will stimulate research and development on the part of individuals and corporations and so result in building up in Canada a basic iron and steel industry.

16. *The Utilization of the low-grade Lignites of Western Canada for domestic fuel.*—The report of the operations, for the last year, of the Lignite Utilization Board appears as Appendix E. In this report the difficulties which the Board has had to meet in the carbonizing and briquetting of these lignites on a commercial scale are fully set out and it is satisfactory to note that these difficulties are in great part overcome and that the work of installing a plant near Estevan in Saskatchewan has gone so far as to make it certain that in September or October next it will begin operations on a scale to turn out about 30,000 tons of briquettes per year.

The report emphasizes the fact that the cost per ton of the briquettes to be produced is likely to exceed the estimate given in the Report No. 1 of the Council, "The Briquetting of Lignites", prepared in 1917. The increase is due to the increase in cost since that year of all the items which had to be taken into account in making this estimate. It is, however, certain that the price in Manitoba and Saskatchewan of anthracite, to which the briquettes of carbonized lignite will be approximately equal, ton for ton, in heat value, will very considerably exceed the price current in 1917 and in consequence the briquettes will be much in demand. With a decline in their cost, which will undoubtedly result eventually from a reduction in the cost of the raw materials and the operating processes the demand for them will increase, more especially as the price of anthracite, it is exceedingly probable, will go still higher or the quantity of it which will reach Western Canada will be exceedingly limited.

As the report points out the commercial success of the demonstration of the briquetting lignites will inaugurate the development by private capital of the briquetting industry on a very large scale in the next few years in Western Canada.

17. *The work of the Committee on Industrial Fatigue.*—The work of this Committee, a report of which is given in Appendix G, has been carried on on a tentative basis during the year, with the object of determining along what line ultimately the activities of the Committee should be most profitably directed. The work of the British Industrial Fatigue Board has resulted in a large amount of information of value as applied to British industries, and investigations carried on under the Federal Health Department at Washington, at Harvard and John Hopkins Universities, indicate the nature of the problems concerned in American industries, but in either case the ground covered is not all-comprehensive and it appeared possible for the Committee to select several of the problems, the investigation of which would not involve duplication of the work done abroad. This necessitated some preliminary survey which the Committee began on the following:—

(*a*) The present situation in regard to industrial hygiene and social welfare in certain representative industries.

(*b*) The amount of lost time due to sickness and the amount of labour turnover.

(*c*) The incidence of occupational diseases in certain industrial lines.

The work so far on these problems has been chiefly confined to the first, (*a*) and it is expected that during the coming year enough of data will be obtained to enable the Committee to concentrate its energies on a line of investigation distinct from any of those lines undertaken abroad and of special importance to industrial conditions in Canada.

The Committee has asked that its name be changed to that of the Committee on Industrial Hygiene. Soon after it was appointed it was recognized that the name "Committee on Industrial Fatigue" postulated a too limited function, for it was found that all the factors of industrial fatigue are associated very intimately with the health and diet of the worker and the hygienic conditions or otherwise of his environment, not only during his working hours but also of his life outside the factory or workshop. In consequence the change of name appears justified but the reason for the change has raised a question which concerns the future of the Committee.

Public hygiene is one of the functions of the Dominion Department of Health recently established and accordingly to have investigations on subjects in certain lines in industrial hygiene carried on by a committee outside of and not responsible to that Department is contrary to the policy of the Research Council, which has scrupulously avoided any duplication of the work or the functions of a department in the public service. When it appeared that the work of the Committee would inevitably include investigation in industrial hygiene the Administrative Chairman made representations to the Deputy Minister of Health urging that the Department should take over and carry on the work of the Committee which legitimately belongs to it. While recognizing that industrial hygiene is under the control of the Department the Deputy Head of the latter is at present unwilling to assume this control owing to its limited budget which no more than suffices to meet the programme of work of the department.

There is, however, hope that perhaps next year the department may be in a position to carry on this work on an adequate scale as it should be and for the present the Committee must continue the work it has undertaken, the results of which will blaze the path for that department when it assumes responsibility for it.

18. *Forest Studies.*—In Appendix F is given the report of work and investigations carried on, during the season of 1919, on the Petawawa Reserve by the Forestry Branch of the Department of the Interior. This work, it may be recalled, was begun in 1917 with the aid of a grant from the Research Council and continued, similarly supported, in 1918. In those two years the portion of the reserve surveyed was about 55 square miles. The grant for 1919 was $6,282.32 and the work then done practically completed the preliminary survey of the remainder of the one hundred square miles approximately of the reserve. The final report of this preliminary survey, which will be available shortly, will render a complete account of the work of the last three years.

The object of this survey, it is stated in the report for the year 1919, "is to delineate and describe the various forest conditions; to gather data in regard to topography, soil, distribution of age classes, growth, available supply of saw timber, etc.; in short to collect all such information as will be of help in planning the organization and management of the experimental area." All this information is to be used to

determine ultimately the scientific conditions on which effective reforestation may be carried on in Eastern Canada.

The data so far thus obtained are numerous and of value but the survey and the necessary investigation associated with it must be continued on a much larger scale, for at least ten years further, in order to command all the information necessary to attain the ultimate object of these studies.

The reserve, in many respects, is admirably fitted to serve for such investigations. It was originally covered with white pine and other important timber trees and its capability for such timber growth has thus been shown. There is now a young forest of these trees covering the greater part of the area, thus furnishing the material on which to make the initial measurements necessary for the determination of rates of growth in volume and the possibilities of reproduction of these trees. The area is also large enough and the character of the soil and its conditions varied enough to represent all the conditions which occur either singly or together in other areas which it may be desirable to reforest. Further the reserve is under the control of the Dominion Government, through the Department of Militia and Defence and being easy of access from Ottawa the work carried on there may be readily kept under supervision by the Forestry Branch during the whole of each year.

The Research Council has hitherto, so far as its parliamentary vote permitted, assisted these forestry studies because the problem of reforestation, in view of the threatened depletion of our forest resources, is amongst the questions of the first order of importance to Canada and because also they must be pursued in order to provide the knowledge absolutely necessary for successful reforestation on a large scale. The Council has, further, provided a grant of $8,000 to continue the studies in 1920. It, however, recognizes that, begining next year, the survey must be carried on on a large scale and on a plan that will provide for systematic and co-operative investigation throughout each of the succeeding ten years. This will entail the erection of stations and a laboratory on the reserve and the maintainance there almost continuously of a staff of expert observers. This will involve a large expenditure, quite beyond the means of the Council to meet, and in consequence, and as such work is a function of the Forestry Branch, it is of the opinion that an appropriation to be expended by the Branch to cover such investigations for the next five years should be included in the estimates for 1921. The Council believes that it is only in this way that the studies already begun can be carried to a conclusion with results that will guarantee successful reforestation in Eastern Canada.

19. *The Establishment of a National Research Institute for Canada.*—The Research Council early in 1918 presented to the Sub-Committee of the Privy Council for Scientific and Industrial Research, and to the Reconstruction and Development Committee of the Government, an urgent recommendation that this Institute be established at an early date, with the functions of a Bureau of Standards and to provide facilities for research carried on and maintained by associations or guilds for research formed in the various lines of industry in Canada. This recommendation led on April 24, 1919, to the formation of a special committee of the House of Commons "to consider the matter of the development in Canada of Scientific Research, with power to call for persons, papers and records and to examine witnesses under oath, and to report from time to time." This Committe consisted of the following members of the House of Commons: Messrs. Béland, Cronyn, Elkin, Keefer, Kennedy, Lemieux, McCrea, McCurdy, McGibbon (Muskoka), Maclean (Halifax), Nickle, Nicholson (East Algoma), Reid (Mackenzie), Ross, Sheard, Sinclair (Antigonish and Guysborough), Sinclair (Queen's, P.E.I.), Stevens, Thompson (Yukon), Tweedie, and Whidden.

This Committee, under the chairmanship of Mr. Hume Cronyn, held ten sessions at which hearings on the subject of the promotion of scientific and industrial research in Canada were accorded to a number of members of the Council and of the scientific

staffs of various Canadian universities and to representatives of a number of the Scientific and Technical Societies and Institutes of the Dominion, of certain Government departments, and of the Canadian Manufacturers' Association. Dr. S. W. Stratton, Director of the Bureau of Standards at Washington, Mr. W. A. Hamor, Assistant Director of the Mellon Institute of Industrial Research of Pittsburgh, Pa., and Professor Dayton C. Miller, of the Case School of Applied Science, Cleveland, Ohio, also appeared before the Committee and gave very interesting and valuable addresses on the methods to be taken to promote scientific and industrial research.

This Committee in a report to the House of Commons on July 1, summarized its conclusions in the following:—

> "Your Committee feel that the time has arrived when further steps must be taken and additional financial support be available if this country desires to make a proper use of its potential assets and to attain or maintain its standing in the commonwealth of nations.
>
> "The attention of your Committee has been directed to the fact that there does not exist in this country any institution corresponding to the Bureau of Standards at Washington. As a result, Canada is dependent on the neighbouring republic or on other countries for information and guidance in matters which vitally concern her industries. A study of the evidence submitted will convince any impartial student of the weakness of our position in this regard and of the need for a speedy remedy. Your Committee, therefore, recommend to the consideration of the Government the establishment of a Dominion Bureau of Standards.
>
> "Your Committee further recommend that concerted and continued efforts be made to place before the people of Canada the facts regarding scientific research and the far-reaching advantages to be derived from national support thereto. It is plain that outside of a limited circle even the best informed and most influential citizens are sadly lacking in knowledge on this important subject.
>
> While your Committee, as above stated, are unanimous as to the need of co-operation and national support of Scientific Research, yet a majority of its members, owing to the lack of time and pressure of other parliamentary duties, feel they have been unable to so consider and digest the evidence adduced and the other material brought to their attention as to advise the House at this time what may be the best methods of aiding and encouraging Scientific Research throughout Canada."

This report, which was unanimously adopted by the House of Commons on July 3, included a recommendation that the Committee should be reappointed as early as possible in the next (regular) session to give further consideration to this matter and to report to the House of Commons for consideration proposals dealing therewith.*

In support of the proposal to found a National Research Institute for Canada there has been a gratifying unanimity of opinion amongst a large number of Boards of Trade, of Canada, Kiwanis and Rotary Clubs, Institutes, and of branches of the Canadian Manufacturers' Association, as shown by the resolutions which they have sent to the Committee and to the Research Council. This indicates quite clearly that the necessity of founding a National Research Institute for Canada is widely recognized.

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*This Committee was reappointed on March 23, 1920, and has reported recommending the establishment of a National Research Institute for Canada and that an appropriation be made of $600,000 to meet the cost of the site of the Institute, of the construction of the building required and of the scientific equipment of the same, and of $50,000 for the salaries of the staff during the first year. This report was unanimously adopted by the House of Commons on May 7.

The Council would again call attention to the urgency of this Institute as a measure of national importance to Canada. Such an Institute is necessary not only for providing the Dominion with the equivalent of a Bureau of Standards, but also to enable Canadian industries to meet the competition from abroad, aided as this competition is now and will be, by all the resources that scientific research, of the most advanced character, will place at its command.

The Bureau of Standards at Washington has established an Industrial Research Institute in the recently completed building, erected for a War Service Department, which has been presented to the Bureau by President Wilson. In this Institute researches on an extensive scale will be undertaken in all the lines of industries which may choose to avail themselves of the facilities offered by the Institute. This Institute is bound to be of the very greatest service to the industries of the United States and this has a significance to Canada that cannot be too strongly emphasized.

Owing to the importance of the subject, a special portion of this report (section II) is devoted to the part that the National Research Institute will play in assisting research in Canadian industry and more especially through the formation of Associations or Guilds for research in each line of industry. A very considerable number of such Associations have been formed in the British industries and their formation in the United States is being promoted by the National Research Council. The formation of Guilds for research in the Canadian industries depends as indicated in section II on the establishment of a National Research Institute.

II. INDUSTRIAL CO-OPERATION FOR RESEARCH.

The organization of the industries to promote research on the problems which they have to solve in order to meet competition is a subject to which much attention is now being given in Great Britain and the United States and it is one of special interest to all who are engaged in promoting measures which will enable Canadian industry as a whole to move to a position at least abreast of the more progressive element in British and American industry.

The subject was given extended consideration by the Research Council in 1917 and 1918, but the solution offered depended for its success on the establishment in Canada of a National Research Institute and in consequence the Council during 1919-20 specially directed its energies to the achievement of the latter very urgent object. Now that the establishment of this Institute is in more or less immediate prospect it is advisable that the scheme of organization of the Canadian industries for research which the Council recommended should be again emphasized and that a campaign of education on the subject should now be undertaken in the various lines of industry with the object of promoting the right organizations for this purpose.

To facilitate this propaganda it is necessary to discuss the subject once more and especially in the light that the developments of the last two years have thrown on it.

In the report of the Administrative Chairman for the year 1917-18 the way in which scientific research, as an aid to the development of industry, could be applied effectively and on a large scale was discussed at some length and it was shown that this aid could be most efficiently rendered through the formation for this purpose of a co-operative Association in each line of industry in Canada to consist of all the firms or companies engaged in each such line. Each such Association or Guild, as it was called, would provide funds by assessing its members, and the funds so collected would be used to meet the expenses of the researches it would undertake as well as to provide for other objects of the Guild. The funds each Guild so provided could be expended by a committee or board appointed by the Council or the Guild, and the results of the researches obtained would be available for the benefit of each firm in its membership. The members could be accorded other advantages as this arrangement might admit. Amongst such, it was suggested, were:—

1. The right to recommend specific problems for research, which would be passed on by the board or committee, and, if approved, carried out without cost to the firm recommending that the research be undertaken.

2. The right to a periodical service of information for the purpose of keeping a firm in touch with all the technical developments in the industry, even to the extent of receiving copies of articles, translated if originally in a foreign language, bearing on any subject concerned in the industry.

3. The right to the free use of all patented or secret processes which may result from the researches undertaken by, or at the expense of, the Guild.

It was also indicated that firms in an industry not members of the Guild would be excluded from all these privileges and especially from the use of the patents granted to the Guild and that all information as to secret processes would be withheld from them.

The report referred to, then dealt with the question of how far the State should assist such Guilds as follows:—

> "How far aid should be extended to such Guilds must be determined by the conditions attendant upon each line of industry. Ordinarily, when given it should not, except under special circumstances, be in a direct form but in such a way as to stimulate to the utmost private effort and enterprise in industrial research. If a Guild were provided with ample resources of its own for this purpose, it would be in a position to provide its own laboratories and maintain them and a staff for research to the extent required. For Guilds less well circumstanced such establishments are impossible, for the erection and equipment of small independent laboratories will be beyond their means. To reduce the burden to such and to enable them to concentrate their resources on their necessary researches, it would be advisable for the State to provide them room accommodation in a large laboratory with free light, heat, and, where necessary, motive power, and in which they could place research staffs maintained by them. Relieved thus of the initial cost of laboratory construction and of the expense of the maintenance of the laboratory rooms, each Guild could devote all its funds for research to the solution of its immediate and urgent industrial problems."

The laboratory would be that of the National Research Institute for Canada. The staff of this Institute, in addition to the duties it would have of directing and carrying on research in its own proper sphere, would serve in an advisory capacity to research staffs appointed by the Guilds to investigate their own problems. Moreover, with common heating and lighting equipments, the overhead expenses of such united Research Institute and Guild Laboratories would be reduced to a minimum.

In advocating the formation of such Guilds for Research in the various lines of industry in Canada the Research Council followed the example set by the British Research Council, which as early as 1916 began to advocate formation in the various lines of industry of Trade Associations for Research with, approximately, the same function as those outlined, as above, for the Guilds for Research. The reasons for the constitution of these co-operative associations in Canada are the same as those which influenced the Imperial Department of Scientific and Industrial Research to promote the organization of the Trade Associations for Research. There is the fact, for instance, that the great majority of the firms in a line of industry are, individually, unable to provide for expenditure for research on a scale that would insure adequate results. Improvements in processes of production over those now employed, and in the products themselves, can only be obtained through new knowledge that research brings. This research involves very considerable expenditure if it is to be at all of value. Laboratories have to be established and maintained and a staff highly qualified and trained in research must be employed continuously.

This means an annual outlay in the great majority of cases of more than, and perhaps, in some cases, much in excess of, $30,000, an amount that is out of question except with firms with a large amount of capital and a very considerable output in production.

It must also be emphasized that firms which cannot avail themselves in some fashion of the resources that research of the right kind furnishes must in the end be seriously handicapped in competition with rivals which do generously provide for research. All their technical processes of manufacture based on knowledge of the empiric kind or on scientific methods may be known to their rivals while those of the latter may be secret or be patented as a result of the researches for which they are able to provide. There can in the long run be but one outcome of such competition.

That such competition is likely to develop abroad may be predicted with certainty. Already there are some sixteen Trade Associations for Research formed in Great Britain under the auspices of the Department of Scientific and Industrial Research and it has been announced that some eleven or twelve more are either in the course of formation or in the inception stage of the same (*vide* Appendix M). Further, the National Research Council at Washington has been for the last year, and is now, active in the promotion of such Trade Associations for Research in the United States and some success has already attended its efforts along this line. Research Associations on alloys, cotton, glass, baking, etc., are projected or in the course of formation. There are indeed many firms in the various lines of industry in the United States which, individually, have thoroughly equipped laboratories with staffs for research of the most highly qualified kind, and in consequence they do not require to become members of such Trade Associations, but there are very many more each with a moderate amount of capital, for which co-operation is the only way in which they can avail themselves of the benefits of research. That such Trade Associations will be of the greatest service to its members is not open to doubt, and it is likely that under the influence of the National Research Council a considerable number will be constituted in the next few years. The membership in each will be large, for the number of firms in each line of industry, with a few exceptions, is much greater than in Canada, and in consequence the funds for research which such Associations will command will be quite ample to undertake research on a very large scale. One of those now formed—that concerned in petroleum—has already at its disposal more than $1,000,000. With such resources the Trade Associations of the United States will be able to provide their own laboratories and engage researchers whose training, attainments and achievements will be a guarantee that the results which they will obtain will greatly benefit the industries concerned. With more than thirty such Trade Associations functioning in the United States a new era in industry will begin, as, for the same reason, it has already begun in Great Britain.

The funds at the command of the British Trade Associations put their successful operation beyond peradventure. They are obtained by assessing firms in the membership according to some basis agreed upon at the time the Association is formed, but if they are not in any one case sufficient to cover the necessary expenditure the Department of Scientific and Industrial Research will contribute annually for a period of years an amount, to be agreed between the Council of the Association and the Department, but except in cases which call for special consideration the annual contribution of the Department will not exceed £5,000 at most, or the amount raised by the assessment of the firms in the membership of any particular Association. The provision which may thus be made to secure adequate funds for research for the various Associations should enable these to prosper and to become permanent foundations.

The formation of such Trade Associations in Great Britain and the United States is of unmistakable significance to Canada. The industries of Canada cannot remain indifferent to the part they will play in changing the conditions of production in favour of their competitors abroad, and they must organize to promote to the same extent research as an aid to their own development. They must also form Co-operative Associations or Guilds for Research. (*Vide* Appendix N).

There are a number of lines of industry in Canada in which such Guilds could be formed and amongst these may be mentioned the tanning, the textile, the pulp and paper, the furniture, the rubber, the fisheries, the canning, and the clay products industries. These are all important to the industrial development of the Dominion and if the firms in each of these lines were brought to form such Guilds with ample funds at their disposal, the results eventually obtained would be greatly to their advantage in their struggle to win against outside competition, assisted though it will be through research.

The number of firms, however, in any Canadian industry, are fewer and, with some exceptions, of smaller capital and output than those in Great Britain or the United States and consequently the funds which they may pool for research cannot be of a magnitude to compare with the funds of the Associations formed abroad. They cannot, therefore, hope to engage in research work on a sufficiently large scale unless aid is extended to them from some quarter. It is doubtful if public opinion would sanction direct public grants to them such as have been made by the Department of Scientific and Industrial Research to the British Trade Associations for Research. Any assistance extended to them must be of an indirect character and sufficient to relieve them of a considerable portion of the expenditure for research which, without such assistance, would be beyond their means. The cost of the erection, equipment and maintenance of laboratories is a very considerable item in such expenditure and might readily be as much as half of the whole. If relief could be extended so as to cover this portion of the expenditure all the funds of the Guilds pooled for research would go to the payment of the salaries of those engaged to carry on research on their problems and they would thus get the maximum of service for their expenditure. A Guild with an income of $30,000—$50,000 derived from assessment of its members could thus do much in providing for research as a British or American Trade Association with twice the same income. It could thus engage and maintain in its service a fairly large staff of the most highly qualified research type.

To extend this relief will not be difficult if the proposed National Research Institute for Canada is founded in the next year or two. The first laboratory building of this Institute, of the size suitable for the earlier years of its activity, besides providing administration offices, would contain more than fifty laboratory units a dozen or more of which could be placed, for some years, at the service of the Guilds, rent-free and with free light, heat and, where necessary, motive power. The assistance so given, while of a negligible cost to the Dominion, would be of inestimable value to the industries which organized Guilds for Research.

Some advantages, it may be pointed out would result to the public from this centring of the research staffs of the Guilds in the proposed National Research Institute. It would bring the staff of the Institute into intimate contact with the industries of the country and this would tend to focus the attention of the researchers on many of the very problems which concern the industrial development of the Dominion which the Institute would be founded to promote. There would thus ensue an intimate association between the Institute and the industries that would greatly increase the effectiveness of the former as a national institution.

Such an association is now being brought about in the Bureau of Standards at Washington. A new building, of very large capacity and of the most solid construction, erected in the immediate vicinity of the laboratories of the Bureau and designed for war service, but completed only in November of 1919, was given to the Bureau by President Wilson and is to be used for industrial research on a large scale, for which it is admirably fitted. It will parallel in many respects the Mellon Institute for Industrial Research at Pittsburg which has already been of great service to certain lines of industry in the United States. The addition to the present activities and

functions of the Bureau of Standards of such as those which the new Industrial Research Institute will exercise will at once very greatly enhance the value of the Bureau itself to the nation and profoundly affect ultimately the development of its industries.

The accommodation of the research staff of the Guilds for Research in the proposed National Research Institute would greatly promote their efficiency. In some lines of industry there are common problems or problems closely related and there are, therefore, possibilities of duplication or overlapping and accordingly unnecessary expenditure. With the research staffs of such industries working under the same roof this can be readily prevented and the activities of each may be guided so as to bring about a co-operation in all the researches undertaken.

A very great advantage to the industries would accrue from the research staffs of the Guilds being in close association with the staff of the Institute. This staff must be composed of a number of very highly expert specialists in research in the various fields of pure and applied science. The members of the staff would, therefore, be qualified in the highest degree, each in his own line, to act in any advisory capacity to one or more of the research staffs of the Guilds housed in the Institute, not occasionally but continuously. This and the association, under the same roof, of the research staffs of all the Guilds would promote, amongst them, a spirit of emulation in research that would make every researcher keen to achieve the utmost of which he may be capable. The Guilds would thus get a service which it would be impossible to provide them if they were not associated with the Institute.

The formation and the successful working of such Guilds in Canadian industries, therefore, depends on the establishment of a National Research Institute. Through such Guilds only can the great majority of the Canadian industries be assisted to meet the needs in Scientific research which the conditions of to-day impose on them. Without the new-knowledge that research will bring them they will not hold their own in competition with their rivals abroad who are organizing to apply research of the most advanced kind to the solution of the problems which concern their very existence.

The establishment of a National Research Institute which primarily is necessary to promote a great increase of the developed wealth of Canada is, therefore, also necessary to the development of the industries of the Dominion and to enable them to hold their own not only in the home markets but also abroad. *The urgency of the establishment of this Institute is, therefore, of the first order of importance and every year lost in effecting this establishment will increase the difficulties which Canadian industry will face in competition with industry abroad, aided by all the resources that scientific research will place at its command.*

The Council, therefore, once more urgently recommends the immediate establishment of the National Research Institute to enable Canada to develop its wealth, and its industries to hold their own, not only in the home markets but also in the international field.

Pending the hoped-for result of this recommendation the work of promoting the formation of Guilds for Research must be of the first order in the programme of the Council during the next two years.*

*In order to facilitate this promotion the Circulars of the British Research Council indicating the procedure followed in the formation of the Trade Associations for Research in Great Britain are reproduced as Appendices.

APPENDIX "A"

REPORT OF THE ASSOCIATE COMMITTEE OF CHEMISTS.

The annual meeting of the Associate Committee of Chemists of the Honorary Advisory Council for Scientific and Industrial Research was held in the Chemistry Building of McGill University on May 15, 1919. Thirteen of the eighteen members were in attendance. The Chairman, Dr. R. F. Ruttan, briefly reviewed the activities of the Advisory Council for the year 1918, so far as they were specially interesting to chemists. He stated that the "Census of Chemical Industries of Canada", which was recommended at the last meeting of the Associate Committee had been prepared and was ready for distribution. He reported that a system of bursaries for distinguished graduates, who had not had an opportunity for showing their ability for research, had been established, of the value of $500 per annum. The Advisory Council had also arranged that those holding Fellowships, etc., as well as those engaged in researches assisted by the Advisory Council, would be able to patent their discoveries, if of commercial value, under very favourable conditions.

The difficulty of obtaining publication of important scientific papers was discussed, and the Chairman announced that the Advisory Council would probably subsidize the Royal Society of Canada to cover the cost of printing the more important papers in the Transactions of that Society.

After referring to the various researches which were being carried on with assistance from the Advisory Council, the Chairman reviewed the proposed legislation in favour of establishing a National Research Institute and stated that this question would be up for consideration before a committee in the House of Commons during the next Session.

The development of an industry in connection with the utilization of fish waste had not made the progress hoped for by the Research Council, but the publicity given to the question by the Council had led to the formation of a private company to utilize the fish waste at Canso, N.S., by manufacturing from it a high-grade cod-liver oil, stock and poultry food, as well as fertilizer.

In discussing the points arising from the opening address, the Committee heartily endorsed the idea of a Research Institute and also the idea of extending the system of Fellowships so as to include the Ramsay Memorial Fellowship, entitling the holder to conduct chemical research in England.

Dr. Macallum fully described the proposed system of Trade Associations or Guilds for co-operative research in the main industries.

The question of establishing an employment bureau for chemists, similar to that in the Chemists' Club, New York, was brought forward by Professor Cameron, of the University of New Brunswick, and was fully discussed, a resolution was passed to take steps towards establishing such an employment bureau, which was asked for by both chemists and employers.

Two papers were read on the training of chemists for industries, one by Dr. McIntosh and one by Dr. Ruttan. These papers led to prolonged discussion, the general result of which was to emphasize the value of research in fundamental problems of chemistry in the universities, in preference to problems involving the application of chemistry to industries. It was also recognized that the training of chemical engineers should involve a certain number of months of instruction in chemical works, and it was thought advisable to thoroughly investigate the possibility of applying to Canada the plan adopted by the Massachusetts Institute of Technology, of giving to students, before graduation, four or five months of experience and train-

ing in chemical industries, under the supervision of a university professor. In this connection, Dr. Macallum brought forward the advisability of limiting the university training for B.Sc. degree to three years, and reserving the fourth year for graduate work.

It was decided to have the members of the Committee retire annually in groups of five, thus permitting each member to serve for four years on the Committee. The order of retirement is as follows:—

To retire in 1919.

Dr. W. H. Ellis, University of Toronto.
Dr. W. L. Goodwin, School of Mines, Queen's University.
Dr. Milton Hersey, President, Milton Hersey, Ltd.
Dr. R. D. MacLaurin, University of Saskatchewan.
Dr. M. A. Parker, University of Manitoba.

To retire in 1920.

J. B. Bell, Jr., M.Sc., Can. Explosives Co., Ltd.
Professor Adam Cameron, University of New Brunswick.
E. A. LeSueur, B.Sc., Consulting Chemical Engineer.
Dr. E. Mackay, Dalhousie University.
H. W. Matheson, Can. Electro Products Co., Ltd.

To retire in 1921.

J. W. Bain, B.A.Sc., University of Toronto.
Dr. F. J. Birchard, Dominion Grain Laboratory.
Dr. F. M. G. Johnson, Can. Consolidated Rubber Co., Ltd.
Dr. D. McIntosh, University of British Columbia.
E. Bernard Smith, Dom. Tar & Chemical Co., Ltd.

To retire in 1922.

Dr. John S. Bates, Price Bros., Ltd., Kenogami, P.Q.
Dr. A. F. L. Lehmann, University of Alberta.
I. C. Mackie, Dominion Steel Corporation.
T. H. Wardleworth, Nat. Drug & Chemical Co., Ltd.

The second session of the Associate Committee was opened by a discussion on excise duties charged for acetic acid and alcohol. It was pointed out by Mr. Matheson, of the Electro Products Company of Shawinigan, that the present regulations regarding excise duties on acetic acid would prevent the sale of glacial acetic acid in Canada for commercial purposes, and it was resolved, that in the opinion of this Committee, the restrictions regarding the use and sale of acetic acid should be removed, and that Article 366, of Bill 76, be changed with this object in view. It was decided to appoint a committee, consisting of Dr. Ruttan, Dr. Macallum, the Administrative Chairman, and Mr. Wardleworth, to again interview the minister regarding the importance of industrial free alcohol in the development of chemical industries in Canada.

Professor MacLaurin gave an interesting address on the development of the natural resources of Canada, calling attention to the waste of coal, both in mining and in utilization, also to the development of the oil, bitumen and gas deposits in Canada. He called attention again to the vast quantities of iron ores existing in the Dominion, of which only a small percentage is being used. The loss of fertilizers, resulting from the waste straw, was also thoroughly demonstrated. He called attention to the fact that it would be possible to obtain economical gas, for use in farmers' houses, from the utilization of straw, the resulting carbon also would have a commercial value.

DEVELOPMENTS RESULTING FROM THE ACTIVITIES OF THE ASSOCIATE COMMITTEE OF CHEMISTS.

The fish waste industry during the past year has been developed by a private company, controlled by American interests, as it was not found possible to obtain Canadian capital. The results of the few months' trial demonstrated that a valuable cattle food could be prepared by mixing fish waste products with flour mill refuse and other by-products resulting from the manufacture of cereals, etc. Several carloads of pure cod-liver oil were shipped to Boston, which met with the requirements of the British and American Pharmacopœia. It is now proposed to increase the original plant to such an extent as to produce five times the product obtained in 1919. This will involve an additional outlay in plant of about $300,000.

"The Census of Chemical Industries" was so greatly sought after by manufacturers that the first edition published in June was exhausted during the summer and another is in course of preparation.

In May, 1919, at the time of the meeting of the Associate Committee of Chemists, and largely aided by them, the chemists of Canada became united under the name of "The Canadian Institute of Chemistry," and a tentative constitution was drawn up which will be confirmed at the next annual meeting. This new Institute was represented by Dr. Ruttan at the meetings held in London and Brussels in July, 1919, for the establishment of the International Union of Pure and Applied Chemistry, and subsequently declared its adhesion to the International Union. A representative will be sent to the first annual meeting in 1920.

On the recommendation of the Associate Committee, the Institute of Chemistry has undertaken the establishment of a bureau of employment and technical information for the chemists of Canada.

The following chemists were recommended by the Committee and appointed by the Advisory Council to replace those retiring in 1919:—

Fred J. Hambly, F.I.C., Electric Reduction Co., Buckingham, Que.

Robert Job, A.B., Milton Hersey Co., Ltd.

Arthur C. Neish, M.A., Ph.D., Queen's University,

Prof. J. W. Shipley, M.A., Ph.D., Manitoba Agric. College,

Harold Van der Linde, Van der Linde Rubber Co., Toronto.

(Sgd.) R. F. RUTTAN,
Chairman.

Upwards of eighty inquiries regarding the chemical manufactures have been received and replies sent. To some inquiries it was possible to give the information at once, but in the majority of cases the inquirer was referred to some authority for fuller details. The Chairman wishes to thank the members of the Associate Committee for their assistance. To give some idea of the variety of questions submitted, the following list has been compiled:

Acetic acid and bichromate of sodium, market for.
Alcohol for motor fuel.
Alcohol from sulphite liquors.
Alcohol from wood waste.
Aluminium from clay.
Ammonium chloride in Canada, market for.
Anhydrous ammonia plants.
Arsenic in Canada, market for.

Bent wood furniture, manufacture of.
Birch oil, sources and nature of.
Bone charcoal, sources of supply of pure carbonate of lime, infusorial earth.
Calcium carbide, lime for.
Casein, products of.
Cotton seed oil in manufacture of sardines.
Drying of foodstuffs.
Ethyl benzoate, market in Canada for.
Fish oils, purification and market for. (Several letters.)
Fish waste, its manufacture and use. (Extensive correspondence.)
Flax fibre uses in the paper industry. (Several inquiries.)
Glazing for interior of refrigerators.
Granite, cutting and cleaning.
Gypsum, uses and products of.
Humidity in air of room, regulation of.
Hydrogen manufacture in Canada.
Iron oxide paint for asbestos.
Kaolin, utilization of.
Kelp as source of potash and sodium.
Lime, manufacture of.
Manufacture of fertilizer from nitro-glycerine and T.N.T.
Methyl alcohol, use in making collodion.
Methyl chloride and ethyl chloride as refrigerating agents.
Oxylinoleic acid action on sole leather.
Paper from cotton, high-class.
Pine tar, composition of.
Potash from feldspar.
Pyridine, sources of.
Radio-active minerals.
Radio-active process of detection of ores, etc.
Salt in syrups.
Shellac, deterioration of.
Solid alcohol, how prepared.
Sulphur dioxide, market for.
Sulphur flowers from iron pyrites.
Utilization of confiscated opium.

APPENDIX B.

REPORT OF THE ASSOCIATE COMMITTEE ON MINING AND METALLURGY FOR THE YEAR 1919-20.

The chief work undertaken by the Associate Committee on Mining and Metallurgy during the present year was an extended study of the information now available with reference to the iron ores of Canada. A sub-committee, under the chairmanship of Mr. J. G. Morrow, of the Steel Company of Canada, collected all published information with reference to Canadian iron ores, and also secured from various companies and private sources a large number of most valuable confidential reports by competent geologists and mining engineers with reference to the iron ores of Canada.

This whole body of information is now being studied and collated with a view to ascertaining in what way and in what directions the Research Council can bring the resources of applied science to bear upon the solution of the problems presented in connection with the utilization of the iron ores of the Dominion for the purpose of building up on the basis of Canadian ores, Canadian fuel and Canadian power, a great iron industry in the Dominion of Canada.

A full report on this study of the iron ore situation of the Dominion will be presented to the Research Council for action in the immediate future.

Closely connected with the development of Canadian smelting is the question of the possibility of increasing the output of Canadian refractories. Of these the magnesite deposits of the Grenville district in the Province of Quebec are of special importance. In these deposits the magnesite occurs in white crystalline limestone, with which it is very intimately associated and mixed. The purest magnesite always contains a small percentage of carbonate of lime, which does not interfere with its utilization. Great bodies of the magnesite, however, occur mixed with so large a proportion of limestone that they cannot be employed industrially. If some satisfactory method of separating these two closely allied substances could be devised, this magnesite might be purified, and in this way an immense additional tonnage would be made available for use and the output of the deposits could thus be greatly increased. This problem of separation is one which could probably be successfully attacked by experimental investigation, and the Associate Committee has approached the Director of the Mines Branch of the Department of Mines, which department has an admirable experimental plant in the city of Ottawa, submitting this matter to them. The Director has undertaken to carry out some experiments on a large scale looking to the solution of this problem, which, if they are successful, will lead to a great development in this new Canadian industry.

The Committee has also made a study of the problem of the utilization of pulverized coal, but having ascertained that experimental work on this subject is now being carried out on a large scale by a number of different bodies, and that the various problems presented are now in a fair way to be solved, the Associate Committee did not consider it advisable for the Research Council to take further action in connection with this question at the present time, and therefore brought their studies to a close.

Mr. Arthur A. Cole, B.Sc., M.A., a member of the Associate Committee, who was also a member of the Peat Commission formed recently through representations made by the Research Council to the Government of the Dominion and the Provincial Government of Ontario, reported that the work of the Peat Commission in the development of the bog at Alfred, Ont., has met with a most gratifying success, and that in the summer of 1920 some 20,000 tons of peat from this bog will be produced and marketed in the cities of Montreal and Ottawa at a price of about $3.50 per ton f.o.b. on the cars at Alfred station. If this fuel meets with a satisfactory sale, the peat industry in Canada will have been placed on a thoroughly sound basis and the way opened up for the utilization of the great supplies of this fuel which are to be found in the many other bogs occurring in various parts of the Dominion.

With the desire to have the immense amount of information concerning the resources of Canada, which exists in the various Government departments at Ottawa, made more readily accessible to the public for the development of our natural resources, the Associate Committee was moved to pass again a motion carried at the Committee's meeting last year, to the following effect:—

> "That in view of the great urgency of this matter, the Advisory Council be requested to continue to press the Dominion Government for action on the proposed Bureau of Information, recommended in the resolution of the Committee last year."

APPENDIX C.

REPORT ON THE WORK OF THE BRITISH COLUMBIA ADVISORY COMMITTEE FOR THE YEAR ENDING MARCH 31, 1920.

During the past year the readjustments in every kind of business made necessary by the demobilization of the army and the general unrest following the closing of the war, has made it impossible for members of the British Columbia Advisory Committee to devote time to questions of scientific research, except in so far as such questions came before them in their individual spheres of work.

It became clear that the Advisory Committee could accomplish little without the aid of a technically trained secretary who could devote a great part of his time to the work, and representations were made to this effect to the Chairman of the Research Council in August, 1919, with the result that in October last the Research Council authorized the appointment of a paid secretary who could devote half his time to the work, and made an appropriation requisite for this purpose.

In November the Chairman of the Research Council made a visit to Vancouver at the time of the convention of the Canadian Mining Institute held in this city, and he had a long discussion with the members of the British Columbia Advisory Committee, in which he outlined the work that had been done by the Research Council, and discussed the appointment of a secretary for the British Columbia Advisory Committee.

At a meeting of the British Columbia Advisory Committee held shortly thereafter, the general opinion was expressed that as nearly all questions and problems coming to the attention of the Committee were chemical or metallurgical in their nature, it would be advisable to appoint a trained chemist as secretary. A sub-committee was appointed to look into this matter and upon their recommendation Mr. Horace Freeman was appointed secretary as from February 1, 1920.

In the short time that has elapsed since this appointment, Mr. Freeman has pursued investigations along several lines with activity, and his reports on the progress of his work are attached hereto.

Of the questions that have been placed before the British Columbia Advisory Committee, two are of principal importance.

The first concerns a laboratory for testing structural materials. In 1918 an agreement was entered into between the Forestry Department and the University of British Columbia for the establishment of a laboratory to test the strength of British Columbia timber. This laboratory was established at the University.

There is, however, in Vancouver no testing establishment of any kind to which engineers or others can take metals or other structural materials to test their physical qualities, and in the opinion of the Committee it is of great importance that provision for such an establishment at the University of British Columbia should be made as soon as possible.

It is suggested that the Research Council might consider the question of an appropriation for the purchase of a 100-ton machine for testing the strength of materials, to be installed in a building provided by the University of British Columbia.

The second question is that of the production of alcohol from sawdust or waste forest products. This important question was referred to the British Columbia Advisory Committee by the Chairman of the Research Council, and Mr. Freeman's report shows the progress of investigation in respect to this matter.

APPENDIX D.

WOOD WASTE IN BRITISH COLUMBIA.

The waste produced in the lumber mills of British Columbia is at present disposed of in three ways:—

(1) The bulk of sawdust and shavings—over 90 per cent—is used for raising steam for use in the mill. A portion is sold to manufacturing plants outside the mills for the same purpose. The high price of coal at the coast tends to promote the sale of the material outside the mills.

(2) Between 60 and 90 per cent of the larger waste is sold for domestic fuel and power purposes in and around the cities.

(3) The remainder, which contains probably 5 per cent by weight, of bark, and is too small to sell for fuel, is consumed in the incinerators.

It may be noted that large quantities of hemlock sawdust are accumulating at various points owing to the difficulty in burning this material, due to high moisture content.

Considering the three classes of waste enumerated above, only unconsumed sawdust and the material sent to the incinerators can be considered as actual waste. Attempts have been made by the writer to arrive at some estimate of the amount of wood actually burnt in incinerators, but there is no direct method of arriving at this, except by the opinions of mill managers, who themselves are frank to confess that estimates are only approximate.

The mills in the city of Vancouver, when running at full capacity, consume between 400 and 1,000 tons of wood daily in the incinerators. The present cost of an incinerator is between $10,000 and $60,000. The latter sum would almost suffice to finance the processing of 50 tons of wood per day for the production of molasses cattle-food, and turn loss into profit.

The upkeep of an incinerator is by no means a negligible item in the cost sheet of a large mill, and in addition, the smoke produced from the incinerators, especially in the city of Vancouver, is so great as to constitute a public nuisance.

Reverting again to the amount of waste consumed in incinerators the writer considers that estimates of 15,000 tons daily are far in excess of the truth, and that with all mills busy, a total of 5,000 tons for all British Columbia is the maximum. A conservative estimate would be 2,500 tons and should be the basis for consideration of any processes for the disposal of this material. At the present time, the waste passing on conveyors to the incinerators is very carefully picked for material that is suitable for fuel purposes. This is due to the high price of coal. The demand for wood fuel falls off in the warm season, and consequently somewhat more is consumed in the burners.

Some method is desired to eliminate (1) the waste of wood, which now goes to the incinerators; (2) the direct expense entailed in creating this waste; (3) the smoke nuisance which results.

A number of methods have been proposed to turn this waste to profit. Those which may seriously be considered as offering commercial possibility are:—

(1) Distillation—producing charcoal and volatile by-products.

(2) Chemical processing to produce—

(*a*) Molasses for use as cattle-food.
(*b*) Ethyl alcohol as a motor fuel to take the place of gasoline.

(3) Production of sulphate pulp for the manufacture of paper.

In considering first the destructive distillation of wood, we find that the Pacific Coast woods are universally low in volatile constituents other than water.

The following data, culled from experimental work carried out at the University of Washington, gives some idea of what may be expected from mill waste:—

Wood Tested.	Wt. of one Cord.	Turpentine and Light Oils.	Tar.	Wood Alcohol.	Acetate of Lime.	Charcoal.	Yield Charcoal.
	lbs.	Gal. (U.S.)	Gal.	Gal.	lbs.	lbs.	%
Douglas fir—							
Average mill waste.....	3,330	3·4	27·8	3·9	75·0	977	29·3
Selected waste.....	4,250	10·8	46·4	3·7	74·0	900	23·5
Western pine—							
Average mill waste.....	3,260	5·6	19·9	2·6	56·0	675	20·7
Western hemlock—							
Average mill waste.....	2,840	4·9	24·8	3·2	73·0	478	16·8

Attempts made to commercialize the dry distillation process in British Columbia have not hitherto met with success, owing largely to the fact that reliance has been placed upon the volatile products to give the main returns, and the charcoal has been regarded as a by-product. Consequently, the plants designed for the purpose have been of such a type that they could not be considered suitable for economically disposing of the large quantities of waste.

If, however, attention had been concentrated upon the production of charcoal as the main product and the volatiles regarded as secondary products, or disregarded altogether, it is probable that the cost of producing charcoal would have been so low as to encourage the use of this material for fuel in competition with coal.

The suggestion is here made that cheap charcoal readily could be produced from mill waste, provided that the plant used for carbonizing were of simple construction, requiring low upkeep charges, and a minimum amount of labour.

Any plant for the purpose should be of such a nature that it could be placed under the present conveyers from the saw-mills, and not increase the fire hazard. It should be continuous in operation and should be able to take care of all varieties of waste and of all the waste as it is sent from the mill. It is possible that such a design would necessitate disregard of all the volatiles except perhaps tar and tar oils. It is probable also that a retort embracing these principles would be considerably smaller than the incinerator required for complete combustion of the wood. Average mill waste will yield 25 per cent of its weight of charcoal containing 12,000 B.T.U.'s per pound. The wet wood from which it is derived contains 4,000 B.T.U's per pound. The charcoal made from one pound of this wood will contain 12000/4, or 3,000 B.T.U.'s, or three-quarters of the heat contents of the wood.

It is for this reason that large incinerators are required, for they must dispose not only of the gases in the wood, but must burn up the fixed carbon. If it were possible to remove charcoal from the incinerator, instead of ashes, only one quarter of the total heat would be generated therein, and the expense of water jackets and periodical relining with firebrick would be avoided.

The writer holds the opinion that wood charcoal at the same price as coal would find a ready market as domestic fuel, and provide a very economical solution of the mill waste problem, bearing in mind the fact that weight for weight, charcoal contains more heat than soft coal, and also less of this heat is lost in the flues, etc., than is the case with coal. Soft coal now in use contains 11,000 B.T.U.'s per pound and from 10 to 25 per cent ash, while charcoal from mill waste contains 13,000 B.T.U.'s and less than 1 per cent ash.

The production of ethyl alcohol from wood waste comprises the following steps:—

(*a*) Comminution of the wood.

(*b*) Digestion of this wood with dilute acid (sulphurous) under pressure. 0·25 per cent of the wood is converted by this means to fermentable sugars. This is done in digestors, such as are used in pulp manufacture. The solution of sugars is separated from the residue pulp and is fermented with special yeast cultures, producing a "beer."

(*c*) The "beer" is distilled and the distillate yields substantially pure alcohol.

The alcohol produced is of the potable variety, and should not be confused with wood alcohol, which is obtained by heating the wood in retorts at a red heat. For this reason the process now under consideration is under the same restrictions that govern the production of pure grain alcohol. Before it can be used as a motor fuel, this alcohol (from wood) must be denatured by admixture, preferably with other combustible liquids which render it non-potable.

The field is not yet clear for the production of motor spirit from wood, owing to the laws restricting the manufacture, the regulations governing the denaturing, which do not allow of this being done at the point of manufacture, and lastly, owing to the lack of a suitable denaturant which must fulfil several conditions, i.e., it must be cheap, combustible, of such a nature as to render the alcohol absolutely non-potable, not allow of illicit purification, and must readily mix wih alcohol.

It has been proposed, pending the removal of restrictions, to conduct the process to the point of production of wood molasses, using this product as a basis for stock food. At any time later the necessary equipment could be added for the production of motor spirit.

The following statement covering the production of molasses was submitted by Mr. G. H. Tomlinson, who has been instrumental in introducing the manufacture of alcohol from mill waste in the United States:—

"The waste at a saw-mill comprises all of the material destroyed either in the incinerator or for raising steam. All of this is available for alcohol (or molasses) production without disturbing the fuel supply for the reason that only 25 to 28 per cent of the actual wood is decomposed in the process. The balance of 75 per cent is still available for raising steam, and will furnish enough power for both saw-mill and alcohol plant.....The presence of the average amount of bark, or chlorides from sea water, does not affect the process.

"The comminution of the edgings, etc., is effected in two operations: They are first put through a hog and then through a shredder which beats them to the desired size. The cost of this operation is approximately 30 cents per ton.

"It is now an accepted fact that a certain portion of wood can be converted into sugar by treatment with dilute acids. By this means at least 25 per cent of the wood can easily be converted, and any technical or engineering difficulties in this connection have been entirely overcome. This process has already been applied on a large scale for the production of ethyl alcohol with satisfactory results.

"Since molasses has come into such generally accepted favour as a feeding material, it has frequently been suggested that this process of wood conversion offers an unlimited means of supplementing our food resources. The mixture of sugar, which is thus obtained, can be separated in solution from the residue and this solution can then be concentrated thus yielding a product substantially like molasses in sugar content and which is quite as acceptable to animals as either the cane or beet sugar product.

"A proper ration for feeding stock should consist, however, of a mixture of concentrated and coarse feeds. The ratio by weight of coarse fodder or bulky material to concentrated feed in the ordinary ration has been found to be 1:1.

"Molasses which consists almost entirely of digestible carbohydrates and may be defined as a super-concentrated feed was used as early as 1830 for feeding horses and has recently come into very general use with extremely satisfactory results. When thus used, it is sometimes sprinkled on dry feed, being first diluted with water, or it is mixed with some material which absorbs it and renders it easy to handle such as peat dust, etc. It is also common practice to mix molasses with the drinking water in a trough allowing the animals to drink from this ad libitum. The best plan, however, is to thoroughly incorporate it with a coarse fodder so that the animals do not become smeared in eating.

"As a part of a mixed ration it has been proved that one quart of molasses will replace three to four quarts of oats; that molasses is a most nutritious food, easily digested and assimilated, and will in many cases correct faulty digestive processes; that molasses-fed horses will do fully as much work and remain in much better general condition than animals fed on dry food, while the cost is reduced. Much more can be said in favour of feeding molasses, but having these general facts in mind, the possibilities in connection with the production of a highly valuable feeding material from wood can be easily deduced, especially in view of the following facts. The product resulting from the hydrolysis of wood if properly conducted yields on the dry wood basis:—

Fermentable sugar (Dextrose)	22.6 %	
Unfermentable sugars (Pentosans) by diff.	1.58%	
Total reducing sugars		24.18%
Non-sugars		3.21%
Total water sol. extract		27.39%
Acid figured as H_2SO_4		2.10%
Insoluble residue (modified or partially digested cellulose,) by diff.		70.51%

"From this it will be seen that the sugars thus formed compare most favourably in nutritive value with the best grades of molasses. Protein and fats are of course negligible as one would expect. By employing a volatile hydrolysing acid such as SO_2 or HCl, using wood which is free from bark and properly distilling off all volatile residues after digestion, the percentage of free acid can be minimized and this when neutralized gives rise to no injurious salts. The insoluble residue resulting from this treatment is completely modified, rendering it an ideal coarse or bulky material to incorporate with the concentrated extract to form a proper ration. The digestibility of this residue has not been determined as far as I know, but it seems likely that it may be relatively high.

"In order to commercialize these possibilities, the following plan is indicated:—

"Hydrolyse the wood with either HCl or SO_2 and then divide the product into two parts. Extract the sugar from part one, render slightly alkaline and evaporate to a desirable concentration. Partially dry the material in part two and then thoroughly mix the product of part one and again dry to a suitable consistency. In this way a product containing any desired concentration would be produced in a form easily handled and ready to use. If desirable some waste product, high in nitrogenous content, such as blood, fish waste, etc., might be added, and in this way a complete or properly balanced ration would result."

Mr. Tomlinson makes an estimate of the cost of producing stock food from sawdust, based on a consumption of 50 tons sawdust daily. The following extract from his estimate is noteworthy:—

Fifty tons sawdust yields 15 tons stock food worth $35 per ton, or $525. The total cost of production is $194, including allowance for the purchase of sawdust at $1 per ton, at point of consumption.

It should be noted that an investment of $100,000 is required for a project of this size. If it be required to produce alcohol, the additional equipment would cost $50,000 and would produce 500 gallons from 50 tons sawdust daily, or 175,000 gallons per annum.

There is no individual mill in British Columbia with 50 tons actual waste sawdust per day, but there are several mills each producing more than this amount of general mill waste. In any case there are mills so grouped that 50 tons clean sawdust could be collected by conveyers and so ensure a constant supply and save the expense of comminuting the wood.

WOOD-PULP FROM MILL WASTE.

Turning now to the possibility of producing pulp and paper from mill waste, it may be said at the outset that this cannot at present be regarded as an economical means for the disposal of any very large portion of the waste that is now being sent to the burners.

Most of the western woods will make a good grade of sulphate pulp, this having been demonstrated in the U.S. Forest Products Laboratory, but to make a commercial grade of pulp the bark must be eliminated.

The cost of purchasing and collecting the wood waste would probably be more than the cost of lumbering selected wood, and the pulp being inferior could not compete for the larger uses of the better grade.

The supply of waste is subject to fluctuation, and this condition would hardly tie in with a pulp plant which requires a steady supply. The investment in a pulp plant is very large and a supply of material for at least twenty years would be a necessity.

Competition with existing pulp plants would require this manufacture to be carried out at tide water, and in conjunction with a reasonably large and cheap supply of power.

It is within the bounds of possibility that the foregoing conditions might be found in the case of one or two individual mills, but the variable amounts and quality of the waste and cost of concentration to a separate point for manufacture operate against the pulp manufacture as a possible outlet for the bulk of the waste.

CONCLUSION.

The writer is of the opinion that the production of charcoal particularly for use as a domestic fuel offers the best immediate means for obtaining revenue from mill waste, and at the same time disposing of the bulk of this material. To this end the charcoal must be produced cheaply and attention should be directed to this point in considering any means for carbonization. Any plant devised for this purpose should be of such a nature that it could take the place of the present incinerators under the conveyers from the mills.

As a means for economically disposing of waste sawdust at some points where mills are grouped together, the production of wood-molasses would appear to be a commercial proposition and might serve as a stepping stone to the manufacture of ethyl alcohol, when the field is clear for the use of this material for motive purposes. This latter manufacture is being carried on successfully in the United States, using mill waste, but the alcohol is not brought as yet into competition with gasoline. An increase in the yield of alcohol might be obtained as a result of research that would change the economic aspect of this process and lead to a very extensive development for wood cellulose.

APPENDIX E

SECOND SPECIAL GENERAL REPORT ON THE OPERATIONS OF THE LIGNITE UTILIZATION BOARD FROM OCTOBER 1, 1918 TO MAY 31, 1920.

The origin of the Lignite Utilization Board is found in the fact that the Honorary Advisory Council for Scientific and Industrial Research was seized, at its first meeting on December 4, 1916, with the gravity of the fuel situation in the West. In Saskatchewan coal for domestic heating reaches its highest price as it is roughly in this region that the increasing freight rates for American anthracite make it possible for the Alberta coal dealers to sell western bituminous coal for domestic consumption in spite of the increased trouble that such coal entails when used in anthracite furnaces during the severe weather. Yet throughout a large portion of Saskatchewan are to be found immense quantities of low grade lignites which unfortunately are not suitable in their raw state for handling in summer, nor have they proved satisfactory in winter for domestic heating, when used in equipment designed to burn anthracite.

A Committee of the Research Council was appointed to consider the whole matter, and as a result of their work, the Council brought to the attention of the Government, in June, 1917, a recommendation that a plant should be erected by the Government to demonstrate the fact that the low grade Saskatchewan lignites can be converted into an efficient domestic fuel by being carbonized and briquetted. When so treated, such briquettes possess practically the same heating value as anthracite. The details of this report to the Government may be seen in Report No. 1, entitled "The Briquetting of Lignites," issued by the Honorary Advisory Council for Scientific and Industrial Research.

In due course the Government in March, 1918, passed an Order in Council recommending an agreement between the Dominion Government and the Governments of the two provinces of Manitoba and Saskatchewan. This agreement was signed on the 20th of July, 1919, and by its terms the three mentioned Governments voted a sum of $400,000 for the carrying out of this project. The whole administration was entrusted to a Lignite Utilization Board, the personnel of which was named by Order in Council on the 2nd of August, 1918.

The Board commenced its actual operations on October 1, 1918, and after digesting all reports and correspondence then on file, sent Messrs. French and Stansfield, their engineer and chemical engineer, respectively, on a long tour of investigation throughout the United States and Canada. During this trip every coal treating plant of any importance was visited, studies were made of all apparatus used and results obtained. It had been hoped that, as a result of such a tour, the Board's representatives would merely have to recommend that for certain processes, certain specified apparatus would be found satisfactory. But in this hope, the Board was greatly disappointed, because it was discovered that in spite of many published reports, American lignites had never been carbonized commercially and the briquetting of carbonized lignite had never been undertaken at all except on the smallest laboratory scale.

It therefore became necessary for the Board to institute a complete experimental investigation in order to avoid the large costs of the almost inevitable mistakes that would be made with full scaled apparatus. To this end, through the courtesy of the Department of Mines, the Board erected in Ottawa a complete carbonizing and briquetting experimental plant, and the following experimental programme was decided upon during the third meeting of the Board held in Montreal, on February 10, 1919:—

1. The weathering and storing qualities of lignite.
2. The heat of carbonization.

3. Rate of carbonization.
4. Atmosphere in retort during carbonization.
5. Special retort of new type developed by the Board.
6. Briquetting investigations covering:
   - (a) Material.
   - (b) Degree of fineness.
   - (c) Binders.
   - (d) Mixers and presses.
7. Smokelessness.
8. Tests of finished briquettes.

Parts of this programme were instituted immediately in March, 1919, but the remaining portions were not prosecuted until later, owing to the extremely slow delivery of apparatus and equipment.

From the nature of the research, some of the items will take an immense amount of time before the work can be finished.

The Board felt, however, that the two main departments of research were those of carbonizing and briquetting. In the early part of the Research Council's work there had been some misconception as to the exact amount of investigation that had been accomplished regarding lignite carbonization. Much of the published material had led those interested to believe that commercial carbonization was "un fait accompli," and that it only remained to enlarge upon existing types of retorts in order to obtain any desired outputs. As mentioned, however, the Board's engineers did not find this to be the case. In fact no commercial carbonization of lignites had ever been accomplished successfully, that is to say, no apparatus existed that would carbonize lignite in commercial quantities at commercial costs. A large number of retorts were examined, but for one reason or other they were all deemed not suitable for the particular work in hand. The Board's staff, therefore, set itself to design a retort along new principles entirely, one in which there would be no moving parts, where high temperatures could be maintained, and where the benefits of so called low temperature carbonization could be obtained. In due course Mr. Stansfield produced a design that was satisfactory to the Board, and a small unit was erected in the Ottawa plant. Upon trial, the new carbonizer developed a certain number of inevitable faults. These were slowly corrected, and by the end of the season of 1919 the Board had reached a position when they were able to state that this problem had been solved.

It next became necessary to devote considerable attention to the question of briquetting. In this field the economical aspects are paramount. There was no doubt in the mind of any member of the Board or of the staff that briquettes could be made with carbonized lignite, but the whole point was, could they be made with a small enough amount of binder to make the product commercial? None of the binders that are satisfactory for lignite, is produced in the vicinity of southern Saskatchewan with the possible exception of petroleum pitch (hydrolene), which at Regina may be refined from crudes. In any event, the increasing cost of oil makes the utilization of hydrolene for a binder very improbable.

All kinds of binders and combinations of binders have been tried. As a matter of record, it may be of interest to know that coal tar pitches, oil pitches, asphalt pitches, lignite pitches, hardwood pitches, sulphite pitches, flour, starch, clay, water glass, cement and straw have all been used with varying amounts of water.

The general conclusion reached by the Board on the question of briquetting may be summed up as follows:—

1. A first-class saleable briquette can be manufactured from carbonized lignite.

2. The quantity of binder is much larger than many investigators have reported. The Board thinks that it is improbable that a good briquette can be produced with less than 11 per cent of those binders hitherto tried.

3. The Board is not restricted to any one binder, but owing to the present excessive cost of other binders, coal tar pitch will be the main binder.

4. The quantity of binder necessary to produce a good briquette with carbonized lignite is roughly double that which is necessary to produce similar briquette from anthracite fines.

In the limits of such a report as this, it is not possible to make any full comment on investigations numbers 1, 2, 3, 4, 7, or 8, other than to say that smokelessness (No. 7) can be achieved by heat treatment after briquetting, but the Board does not feel at the moment that it is probable that such apparatus will be installed owing to the amount that it would add to the selling price of the briquettes.

On the finished briquettes, tests (No. 8) have been given for burning, brittleness, softness, and for the action of frost and water alternately. All the briquettes graded as "good" by the Board have successfully passed these tests.

The general progress of the Board may be outlined in a word or two. In the beginning of October, 1919, at the 4th meeting of the Board, held in Winnipeg, the Chairman announced that briquettes would be on the market by the autumn of 1920. To complete such a programme it was essential to have plans and specifications ready at the earliest date. Consequently the winter was spent in completing the experimental programme, and in preparing designs, plans, and specifications for buildings, plant, and general and special machinery. In addition the question of site was an extremely important one and the Board gave careful attention to it. After a long series of negotiations the Board selected a point about half way between the mines of the Manitoba and Saskatchewan Coal Company and the Western Dominion Collieries. Thus, the supply of raw material (lignite) and of water is absolutely assured independent of weather conditions. The Board have also let contracts for all plant buildings, briquetting machinery, power equipment, conveyers, and within a short time the remaining contracts will be awarded.

It may be not out of place to add a word or two of caution. It must be remembered that the Board's first objective is to erect a demonstration plant. It is far more important, from the point of view of the three governments which are financing the project, to insure that the process itself shall be demonstrated commercially, than it is to state that the actual costs incurred are the absolute minimum per ton of output. It is self evident that, once the process is demonstrated and all pertinent information gained, large commercial plans may be projected subsequently, the designs being laid on the sure foundation of exact operating and technical experience. The operating costs per ton of output of such commercial plants undoubtedly will be lower than those of the present 30,000 ton demonstration plant.

In addition to the foregoing word of caution on the question of operating cost per ton of output, it is desirable to guard against any undue optimism as to the selling price of the finished briquettes. The Board have noted with certain reluctance many extravagant published statements as to the cheapness with which the product would be manufactured and marketed. From its very inception the Board has studiously refrained from making any public statement as to the probable selling price of its product. The figure of $7 per ton at plant mentioned in Research Council's Report No. 1, is a figure that would have been possible in 1917, the date at which the report was written, but to-day is extremely unlikely.

In closing this brief statement the Board wishes to record its appreciation of the co-operation and assistance rendered by the Mines Branch, Department of Mines, Ottawa.

APPENDIX F

REPORT OF THE WORK ON THE PETAWAWA FOREST SURVEY FOR 1919.

The detailed forest survey of the Petawawa Military Reservation begun late in the season of 1917, was brought to completion in the past year by the Dominion Forestry Branch, Department of the Interior.

The appropriation for this work was provided at the request of the Honorary Advisory Council for Scientific and Industrial Research. Permission was granted the Forestry Branch by the Department of Militia and Defence to carry on this survey and also to make silvical and silvicultural experiments on different portions of the reserve.

The reserve proper is approximately one hundred square miles in area and is almost a natural unit, bounded on the north by Corry lake, on the east by the Canadian Pacific railway tracks, and the sand plains, on the south by the Barron river, the only artificial boundary being the west one. It is readily accessible from Ottawa and other large centres, being adjacent to the Canadian Pacific railway tracks and only a short distance from Chalk River, a divisional point on the said railroad where all trains stop. As a forest experimental station which will be of great practical value to forestry, scientists and the public, the reserve presents great attractions not the least of which is its permanency.

Two previous reports have been made for the work done, in 1917 by Mr. D. W. Lusk, in which season the work was begun, and the other report of Mr. R. A. Courtnage on the work done in 1918. These two foresters covered approximately 55 square miles.

The work of 1919 consisted of approximately forty-seven square miles and was divided into three areas as follows:—

(*a*) *First area.*—Work was begun in 1919 on an area of about fifteen square miles situated west of the plains and north of the Petawawa river. This area was of fairly level surface in the western part where it bordered on the plains, but elsewhere there were many variations of slope caused by rocky ridges.

Tucker lake, one of the largest lakes in the reserve, is in the northern part of this area and from the neighbourhood of this lake there is a chain of muskegs and beaver dams draining south into Lock Ian and from there into the Petawawa. The soil in the western part varies from pure sand to a fairly good sand loam with sand subsoil and is very seldom of a rocky nature. Elsewhere the soil is a good sand loam, but generally is shallow and rocky with a rock subsoil.

(*b*) *Second area.*—This consisted of about twelve square miles in the neighbourhood of Cartier lake in the northwestern corner of the reserve. This area is comparatively hilly and the soil is shallow and rocky with the exception of a stretch along the northeastern shore of Montgomery lake. Also southwest of this lake there is a large level area of pure jack pine on which the soil is of a good depth.

(*c*) *Third area.*—This covered about twenty square miles, comprising most of that territory lying between the Petawawa and Barron Rivers. On the whole the surface of this area is fairly regular and slopes are not very steep. The soil is quite shallow and rocky but is nowhere incapable of supporting good forest growth. There are two or three small lakes and a large amount of bog in this area.

A. *The Types.*

White and red pine are the most important species found on the reserve and young even-aged stands, pure or consisting of a mixture of these two species, are scattered over the whole area except the most easterly portion.

Poplar is next in importance and in company with white birch forms another forest type. These species are for a great part only a temporary type because they are short-lived and intolerant and have generally an under storey of pine which will become the permanent type. This type is at present, however, probably the most extensive of all and like most of the growth on the reserve, consists of even-aged stands seldom reaching an age of over sixty years.

Jack pine occurs extensively in large even-aged stands.

Balsam fir, white spruce and black spruce are found on small areas generally on moist soil.

Black spruce of the slow growing bog variety occurs in large areas in almost pure stands.

In swampy places there are often found mixtures of such species as black ash, northern white cedar, balsam fir, yellow birch, black and white spruce.

Red oak grows on the rocky ridges but is of such a stunted and scrubby description as to give little promise of ever becoming of value. Bur oak and white oak have also been noted growing with it.

In some places there are found stands consisting of mixtures of such species as hard maple, red oak, red maple, poplar and birch with small quantities of beech, basswood, ironwood and yellow birch.

The areas which are not at present producing a merchantable crop are open fields, burns not restocking, areas which have been recently clear cut, open muskeg, boggy areas supporting a growth of alders, stunted spruce or tamarack of little value and those areas on which the standing timber has been destroyed by flooding from beaver dams.

The types are then classified as follows:—

Productive areas—	Non-productive areas—
White and red pine	Fields
Poplar, birch	Burns
Jack pine	Cut-over areas
Balsam, spruce	Open muskeg
Spruce bog	Bog with growth of little value
Hardwoods	Flooded areas.
Mixed.	

B. *Types on the Area Surveyed in 1919*

(*a*) *First area.*—The western part of this area consists for a large part of open field as it borders on the military plains. Bordering on the fields and in the north-eastern section is a large area covered mostly with jack pine. Oak takes possession of rocky ridges; there is a large proportion of poplar, birch and a few good stands of red and white pine. On the southwestern part of this area, a few cuttings made by the military camp authorities were encountered. These cuttings were made for the purpose of getting fuel wood and the areas were clear cut, all species being taken (pine, poplar, spruce, birch, ash).

(*b*) *Second area.*—The greater part of this area is dry, rocky and hilly with shallow soil. Poplar and birch cover large areas as does also oak. There are a few good stands of pine, one in particular stretching along the northeastern shore of Montgomery lake and consisting of a mixture of white and red pine in about equal proportions growing in good soil. Southwest of the lake is a large level tract of pure jack pine, also on good soil.

(*c*) *Third area.*—The area immediately south of the Petawawa river between the Crooked and White Horse rapids was one of the most promising pieces of country encountered and it is for the most part covered with young white and red pine. Part of it is pure jack pine and in many places red and white pine is mixed with or is reproducing under jack pine. Immediately south of this area and about a mile from the river there is a good stand of black spruce. The rest of this area contains much poplar, birch, some good pine, some young hardwood and some red oaks, and is typical of the rest of the reserve.

C. *Injuries.*

The physical injuries consist of the effects of fire, lumbering, wind and beavers.

(*a*) *Fires.*—Small fires have been frequent in the history of the reserve. The present even-aged condition of the stands is the result of fires or logging operations, as few parts of the reserve have escaped fire or logging during the last sixty to eighty years. In the western part of the first area, there are a few recent burns, but practically no very recent burns in the second area. In the third area there is a large tract showing the effects of heavy logging and fires, the trees being scattered, of many age classes and of mixed species. Besides a few other recent burns, there is an area northeast of where the Squirrel Depot was situated on the Barron river, which is said to have been burned over in 1917 when the buildings at this place were burned. In some places this fire had the effect of killing the young pine by burning the bark and foliage and leaving the poplar, birch and oak unharmed; in other places it was more severe and burned everything, while on the other hand in some places it did practically no damage, being nothing more than a surface fire.

(*b*) *Logging Operations.*—The effects of lumbering were not particularly noticeable except in the third area where during the last sixty years there have been heavy cuttings. On part of this area reproduction has not been good but generally there has sprung up a good even-aged stand of pine or poplar.

(*c*) *Wind.*—A few individual cases of wind-thrown trees were noticed, particularly in places where the soil was shallow.

(*d*) *Beavers.*—Beavers are an active cause of the destruction of much good timber. A small beaver dam may flood a large area and it is not only bog lands which are flooded, but also the moist soil surrounding the bogs on which there is generally good timber. While causing the drowning out of growth on some areas these beaver dams have also the effect of keeping the reserve in a well-watered condition and of preventing the rapid drainage and erosion which might otherwise take place.

(*e*) *The Pine Weevil.*—As regards biological injury, the reserve is in a very healthy condition, the only important example being the work of the pine weevil. This insect kills the terminal bud and prevents a rapid and straight growth of the young pine tree. Happily this enemy seems to flourish best near fields and open places and so does not affect the main forest.

D. *Reproduction.*

Natural reproduction after the effects of lumbering and fire has been very good and we have as a consequence vigorous young even-aged stands. There are a few tracts, generally of a dry and rocky soil, on which natural reproduction after fire and logging has not been good. Often it seems that poplar and birch are the first species to make their appearance, but merely form a temporary type, as young pine soon appears as an under storey and finally becomes the permanent type. In other places there is no pine reproducing under the poplar birch, but it is a common thing to have a poplar birch type with pine as young growth.

The final report of the forest survey is now in course of compilation and will be available in the next few weeks, complete with map and estimates. The object of this

main survey is to delineate and describe the various forest conditions; to gather data in regard to topography, soil, distribution of age classes, growth, available supply of saw timber, etc., in short, to collect all such information as will be of help in planning the organization and management of the experimental area.

Besides the main survey, a very considerable amount of scientific investigative work was carried on under the direction of Mr. H. C. Wallin. This work took the form of permanently established sample plots for periodic measurements and observation. These plots have so far been of four kinds,—

(*a*) Plots to determine the result of thinning of different degrees and according to various methods. (White pine, red pine, spruce.)

(*b*) Plots established to determine yield of fully-stocked pure stands. Cleaning but no thinning undertaken. (White pine, red pine, jack pine.)

Plots under (*a*) and (*b*) are closely related to each other. Both will furnish us with information on which to base yield tables, plots (*a*) for stands which are thinned by man, plots (*b*) for stands where the thinning is left to nature.

Plots of the (*a*) and (*b*) classes so far laid out number ten. The plots which are thinned have been carefully mapped and described and all data recorded. The trees have been numbered and classified and the location, diameter and tree class of the removed trees, as well as of the remaining ones, are given on the map. On all trees a small cross has been painted at breast height to enable us to caliper the trees at exactly the same place when the plots are again measured. One of the (*b*) plots has also been mapped so that the development of each tree may be followed through later years. The trees are calipered two ways at right angles.

(*c*) Plots to study the development and behaviour of the various species in mixed stands under different conditions, especially with regard to the transformation of the character of the stand. Two plots laid out—mapped and described (Hardwoods.)

(*d*) Plots to study natural reproduction from seed trees or surrounding stand and its development. These plots are fairly large so as to enable a study of the distance from the mother tree reached by the seed. Four plots of this class were laid out, on two of which the brush after logging has been burned.

Some six of these sixteen sample plots were laid out during the past year.

General diameter-volume and diameter-height curves have been plotted, based on 105 red pine, 86 white pine, 76 white birch and 90 aspen. These trees were felled and measured on the different sample plots. The area of these plots varies in extent from 0·3 to 1·6 acres.

In addition to the sample plot work, some 250 different herbaceous plants were collected, pressed and mounted with a view to building up a local herbarium for the use of the technical men attached to the Station.

It is, of course, absolutely necessary from the standpoint of efficiency that the officers engaged in silvical and silvicultural investigation should be acquainted with the ground flora, since the composition of the existing ground vegetation will often be of great assistance to the investigator in judging the suitability of the site in question for the growing of certain species.

Some work of an entomological nature was carried on in connection with the work at Petawawa and a collection of insects made.

The above is a short report of what has been accomplished at Petawawa. It is of course only a small beginning, but it is hoped that from now on we will have the chance and will see our way clear to carry on this work on a much larger scale.

APPENDIX G.

REPORT ON THE WORK OF THE ASSOCIATE COMMITTEE ON INDUSTRIAL FATIGUE.

In July of 1919 a circular letter was sent by the chairman to 72 representative manufacturers in Canada, explaining the purposes of the Committee, and requesting them to state whether they thought this would be of value to Canadian industry, and to offer any suggestions they might have as to particular problems. On the whole the replies were of considerable value, since those received indicated that the work of such a committee, if properly organized, would be of real value to industry and to the worker. It was insisted in several of the replies that it would be useless to undertake the work unless an adequate number of persons were employed by the Committee to devote their time to its various phases, under its guidance. It was decided in the meeting of the Committee in October that the position of Director should be created, to be filled by a person having experience in sociological and related work. The duties of the Director would be to consult with representatives of industry in Canada as to the conditions of industrial hygiene that exist, to recommend to the Committee what could be done to improve them and to carry out under the guidance of the Committee any work that it might approve.

By a canvass of available candidates in Canada, it was found that there is no one with the necessary qualifications at present available for the position.

It was decided at the meeting in December that work should be started in Toronto by the establishment of a local bureau in which all the available literature pertaining to problems of industrial hygiene might be collected, catalogued and abstracted, and that Miss Hutton, should be appointed as Secretary to the Committee, to undertake the supervision of these duties, and to advertise the work and purpose of the Committee by preparation of articles suitable for publication in various journals, and by correspondence. At the same time, the Committee authorized the chairman to employ Dr. Cunningham, Lecturer of Industrial Hygiene in the University of Toronto, to undertake certain investigations into the working conditions in Toronto and neighbourhood. The following is a review of the progress of the work by Miss Hutton and Dr. Cunningham:—

The purpose of the office of the secretary is broadly,—

(*a*) To secure publicity for the Committee;

(*b*) To set up an information bureau on industrial hygiene.

A. *Publicity.*

Manufacturers and others are being informed that the Committee are prepared to do the following:—

(1) To offer manufacturers the assistance of scientific laboratories in solving the health problems presented by the particular processes of their plants.

(2) To offer all interested the use of the Committee's intelligence bureau where the most up-to-date information on general and specific problems of industrial hygiene is kept.

(3) To co-operate in investigations into the health conditions in various industries.

At the present stage it is considered most important to attain publicity of the scope and nature of the work of the Committee. This is being done by contact with—

(*a*) various similar organizations in the United States and Great Britain;

(*b*) various plant physicians, employment managers in Canada, etc.

More directly, publicity has been attained by the following means:—

(1) Articles.

(*a*) *The Journal of Public Health* is publishing in May a 2,000-word article by us entitled "Industrial Hygiene: Need of Research in Canada." They are also publishing at the same time a 500-word editorial by us entitled "Canadian Recognition of the Scientific Basis of Industrial Hygiene."

(*b*) *Industrial Canada*, the organ of the Canadian Manufacturers' Association, is publishing in June an 1,800-word article by us entitled "Industrial Hygiene: Formation of a Committee to be of Practical Help to Canadian Industry."

The editor of this paper is ready to publish other similar articles.

(*c*) An article entitled "Canadian Research into Industrial Hygiene" has been offered to the *Canadian Medical Association Journal*.

(2) Representation at the annual meeting of the Ontario Safety League.

Dr. Macleod and Miss Hutton recently both spoke at this meeting. Dr. Macleod explained the formation and objects of the Committee and invited industry to make use of the facilities offered.

Although the meeting was small the contact established is valuable since persons directly interested in industrial hygiene such as plant physicians, chemists, service and safety men were there and appeared interested in the Committee. Two requests for information have since been received from firms who were represented at the meeting.

(3) Meeting with Dr. Riddell of the Trades and Labour Board, Ontario Government.

Early in the year Dr. Riddell met with the local representatives of the Committee. Dr. Riddell expressed appreciation of the existence of the Committee and showed himself most willing to co-operate with it. He mentioned two problems in which he thought the assistance of the Committee might be useful.

B. *The Information Bureau.*

The Committee is now in regular receipt of the most valuable periodic publications on industrial hygiene of the various Governments, English, Canadian and American. In addition to these "free" publications two periodicals are taken: "The Journal of Industrial Hygiene," and "Industrial Management." So far only a few of the standard books have been bought as it was felt that these could easily be purchased as soon as a demand for them arose. The pamphlet library consisting of the occasional publications of Government Departments, reports of scientific research and trade surveys, etc., amounts to nearly 400 in number and covers the field of industrial hygiene fairly comprehensively. All the material actually in the library, and also references collected from a variety of sources, has been indexed, in some cases in considerable detail, and this index gives a full bibliography of the current literature on the different branches of industrial hygiene.

The problems suggested for Dr. Cunningham's work were:—

(*a*) Investigation of present situation in regard to industrial hygiene and social welfare work in selected representative industries.

(*b*) To ascertain in certain selected but representative industries the amount of lost time due to sickness, and the amount of labour turnover.

(*c*) The incidence of occupational diseases in the industrial survey.

The Committee considered that (*b*) was the most suitable for the first work of the Committee. (*a*) and (*c*) are however, being borne in mind and some data has been collected.

Lost Time from Sickness.—The survey early showed that records of lost time from sickness were the exception. Nine firms with company or mutual benefit insurance schemes had records showing lost time from sickness among those employees who were members. As, however, the visiting was done after absence of varying number of days, the figures are not comparable, and lost time from sickness per member per year ranges from 3 to 13½ days.

Accordingly a record card was drafted based on one proposed for American industry by the United States Public Health Service and adapted by us to Canadian needs.

Twenty-one firms have indicated their willingness to consider its adoption for accident and sickness record.

The majority of managers show considerable interest in the proposal. Some, however, feel that labour unrest makes the present time inopportune for collecting statistics and some are not ready to establish the necessary follow-up system to distinguish between absence due to sickness or accident and absence due to other causes.

Labour Turnover.—Information as to the amount of labour turnover is not available for the following reasons:—

In some firms it is so high that the firms have ceased to keep any record.

In other firms records have never been kept.

APPENDIX H.

REPORT OF ASSOCIATE AIR RESEARCH COMMITTEE.

This Committee was appointed by the Research Council on January 30, 1920, and held its first meeting on February 7th, since which date three other meetings have taken place.

It is understood that its principal function is to make recommendations to the Research Council from time to time regarding the methods to be adopted to organize, assist, and co-ordinate research work in Canada in connection with aeronautics and the aircraft industry. The Committee was established with the full knowledge and approval of the Air Board, and, from the beginning, has worked in co-operation with the Board's officers.

One of the first actions of the Committee was to appoint as Associates a number of gentlemen from various parts of the Dominion who are interested in aeronautical work and are familiar with some phase of it on the experimental side. These Associates are not only available in an advisory capacity, but will, it is hoped, be able to give active assistance in connection with the arrangements for researches to be carried out in different parts of the country. The present list of Associates is as follows:—

Dr. C. Batho, McGill University, Montreal;
Dr. R. W. Boyle, University of Alberta, Edmonton;
Dr. E. Deville, Department of the Interior, Ottawa;
Commander C. P. Edwards, Department of Naval Service, Ottawa;
Capt. R. J. Grant, Willys-Overland, Ltd., Toronto;
Dr. Louis V. King, McGill University, Montreal;
Mr. C. M. McKergow, McGill University, Montreal;
Mr. J. Patterson, Meteorological Office, Toronto;
Dr. J. B. Porter, McGill University, Montreal;
Sir Frederick Stupart, Meteorological Office, Toronto;
Mr. Stanley Smith, University of Alberta, Edmonton;
Mr. W. R. Turnbull, Rothesay, N.B.;

The Associate Air Research Committee has collected data as to the existing facilities for aircraft research in Canada, and regrets to find that these facilities are somewhat meagre, almost the only equipment available for the work being that in the possession of two or three of the larger universities. Further, it appears that research work at these institutions is greatly limited by the absorption of those qualified to carry it out in teaching and routine work.

Communications have been addressed to the Air Board pointing out the necessity of provision for carrying out experimental work on machines in free flight, and it is understood that arrangements to this end will be made when the Board's Air Stations are organized.

Inquiry shows that little, if any, actual construction work, either as regards aeroplanes or aero engines, is now being done in Canada, the factories and equipment so successfully engaged in this industry during the war having been disposed of, and the staff disbanded or turned over to other forms of activity. This regrettable circumstance explains why a request from the Air Research Committee for suggestions from persons engaged, or formerly engaged, in the aircraft industry in Canada, has met with very little response.

The Committee has communicated with the Air Board, pointing out that as an indispensible preliminary to any aeronautical research, information as to what has already been accomplished must be available, and arrangements are being made for the utilization of the valuable information and data now in possession of the Air Board for this purpose. The Committee is also in communication with the authorities in England and with the National Advisory Council for Aeronautics, Washington, and it is hoped to keep in touch with these bodies so as to avoid unnecessary duplication of effort or overlapping as regards researches now in progress in England and the United States.

Considerable discussion has taken place with officers of the Air Board in connection with possible assistance to be given to that Board by the Committee as regards the solution of technical problems involving research. It is expected that the Committee and its Associates will be able to advise the officers of the Air Board, when necessary, firstly, as regards inventions which may be submitted and upon which judgment cannot be passed without investigations to determine the possible usefulness of the invention to the Board, and, secondly, as regards research investigation or advice necessary in connection with the examination by the Air Board Officers of the designs for new or altered machines.

Several suggestions have been received by the Committee as to problems now calling for investigation, of which the most promising appear to be those in connection with:—

Lubrication of aero engines;
Construction of aneroids and barographs with the view of avoiding hysteresis, lag, and other difficulties inseparable from the present methods of construction;
Air speed indicators and other instruments;
Problems in connection with photography as applied to topographical survey work;
Problems in connection with navigation, especially as regards the employment of directional wireless;
Flow of air around aerofoils.

It is hoped that arrangements will shortly be completed for the commencement of work on several of the points named.

From the replies to its inquiries, the Committee has been impressed with the fact that the chief difficulties in organizing aeronautical research work in Canada are,—

(*a*) The lack of trained experimenters with the necessary time for the work in question, and

(*b*) The difficulty in obtaining for these experimenters adequate mechanical assistance for the construction of their apparatus, instruments, and equipment. Both these matters are receiving the close attention of the Associate Air Research Committee.

APPENDIX I.

LIST OF ASSISTED RESEARCHES, 1919-20.

Grantee.	Where carried on.	Subject of Research.	Amount awarded.
			$ cts.
Forestry Branch, Dept. of the Interior, Ottawa.	Petawawa Forest Reserve....	Forestry studies.....	6,282 32
Prof. L. V. King.....	Physics Dept., McGill University.	Research on fog signalling.....	800 00
Dr. A. Stansfield.....	Dept. of Metallurgy, McGill University.	Reduction of iron ores by gases at low temperature and the electric furnace.	1,200 00
E. S. Hopkins.....	Dept. of Agriculture, Olds, Alta.	Investigation of the water requirements of crops in certain soils.	500 00
Dr. A. N. Shaw, Prof. N. E. Wheeler.....	Macdonald Physics Bldg., McGill University.	Investigation on the variations in the conductivity and vapour pressure in thin films of solutions containing highly deliquescent salts as the temperature and concentration change.	200 00
Prof. W. Sadler.....	Dept. of Dairying, University of B.C.	Investigation to determine the grading of cream and butter in relation to the bacterial contents of the cream or milk used in the preparation of these products.	1,000 00
Associate Committee on Industrial Fatigue.	.....	Investigation on industrial fatigue problems.	3,000 00
Prof. J. C. McLennan.....	Dept. of Physics, University of Toronto.	1. Research on the properties of helium.	5,000 00
		2. The measurement of explosive pressures which require a high voltage current apparatus.	1,000 00
		3. Research on molecular physics.	300 00
Dr. J. A. Gray.....	Macdonald Physics Bldg., McGill University.	Investigation to determine the character of the most penetrating type of röntgen rays and their application as compared with the penetrating rays from radium.	1,850 00
Assoc. Committee on Fox-breeding Industry	.....	Investigation of problems affecting the fox-breeding industry.	5,000 00
Capt. F. M. Dawson.....	McGill University.....	Research on the microscopic character of cement in relation to its hydration and its physical properties.	1,000 00
Prof. C. W. Drury.....	Dept. of Mining and Metallurgy, Queen's University.	Investigation to determine the most suitable slag for smelting vanadium ores.	1,500 00

APPENDIX J.

LIST OF FELLOWSHIPS, STUDENTSHIPS AND BURSARIES, 1919-20.

FELLOWSHIPS.

Name.	Where held.	Subject of Research.
K. H. Kingdon	Physics Dept., University of Toronto.	Investigation of the ionisation potentials of gases and metallic vapours.
J. A. McRae (Special Fellowship).	Manchester University, Manchester, Eng.	(*a*) An investigation into the formation of substituted succinic acids by the action of potassium cyanide on the alkylidine cyano-acetic acids. (*b*) A study of the reactions of substituted succinic acids with a view to prepare compounds analogous to the rhodamine dyes produced from succinic acid.
W. F. Seyer	Chemistry Dept., McGill University.	Investigation of the tar sands; the separation of its constituents.
O. J. Walker	Chemistry Dept., McGill University.	Rubber resins: their constitution and relation to the vulcanization process.
F. H. S. Warneford		Deferred until 1920-21.
E. G. Young (Ramsay Memorial Fellowship).	Biochemical Laboratory, Cambridge, Eng.	"The preparation and properties of pure proteins."

STUDENTSHIPS.

H. P. Bell	Dept. of Botany, University of Toronto.	Study of the diseases of the balsam.
Miss E. L. Bishop	Dept. of Physics, University of Toronto.	(*a*) A new form of nephelometer using the plane of polarisation of the scattered light. (*b*) Work on the motion of particles in an electric field.
J. W. Burns	Dept. of Chemistry Queen's University.	Measurement of the hydrogen ion concentration and hydroxyl ion concentration of rare earth salts.
H. R. Foreman	Dept. of Physics, University of Toronto.	Liquefaction of gases with a study of their applications to the production of explosives.
Miss C. W. Fritz	Dept. of Botany, University of Toronto.	Cultural criteria for the distinction of wood destroying fungi.
B. E. Gilbert	Department of Chemistry, McMaster University.	The effect of concentration on the precipitation of pigments in determining the shade of the colour obtained.
Eric Hearle	Dominion Government, Entomological Laboratory, Agassiz, B.C.	Investigation into the mosquito pest of the lower Fraser valley.
O. W. Herzberg		Resigned.
W. A. Lawrence	Dept. of Chemistry, University of Toronto.	Friedel-Crafts reaction on derivatives of phthalic acid.
A. H. Leim	Dept. of Biology, University of Toronto.	The life history of the shad (*Alosa sapidissima*).
A. W. McCallum	Botanical Laboratories, University of Toronto.	Investigation on the biology of *Armillaria*—a wood destroying fungus.
J. W. McKinney	Dept. of Chemistry, McGill University.	The character of the organic matter in oil-shales.
Stuart McLean	Dept. of Physics, University of Toronto.	Investigating the heat of absorption of various gases by charcoals and carbonized lignites.
T. C. McMullen		Resigned.
Miss B. K. E. Mossop	Dept. of Anatomy, Faculty of Medicine, Western University.	The growth of the sea mussel (*Mytilus edulis L*).
Miss M. Newton	Dept. of Biology, University of Saskatchewan.	Resistance of various varities of wheat to the form or forms of *Puccinia graminis* found attacking wheat in the grain-growing regions of Canada.
P. V. Rosewarne	Dept. of Chemistry, McMaster University.	The preparation of toluene derivatives.
Miss E. Shanly	Dept. of Pathology, McGill University.	Bacteriology of canned haddock, also the growth of bacteria in chilled fish (blackening in canned clams).
J. C. Thompson		Resigned.

BURSARIES.

Name.	Where Held.
F. M. Archibald	Department of Chemistry, McGill University.
Miss Lucile Corbett	Dept. of Chemistry, Queen's University.
Miss Elsie Graham	Resigned.
W. F. James	Dept. of Geology, McGill University.
J. H. Mennie	Dept. of Chemistry, University of British Columbia.
H. R. McLarty	Dept. of Plant Pathology, McMaster University.
L. H. Nichols	Resigned.

APPENDIX K.

SUGGESTED DRAFT OF BILL TO AMEND THE PART OF THE INLAND REVENUE ACT DEALING WITH INDUSTRIAL ALCOHOL.

Recommended by the Research Council.

368. In this Part and in any regulation made hereunder, unless the context otherwise requires:—

(*a*) 'denatured alcohol' means alcohol in suitable admixture with such denaturants as to render it in the judgment of the Minister of Customs and Inland Revenue non-potable and to prevent recovery of the ethyl alcohol;

(*b*) 'specially denatured alcohol' means alcohol in suitable admixture with such special denaturants as have been approved by the Minister of Customs and Inland Revenue;

(*c*) 'Minister' means the Minister of Customs and Inland Revenue;

(*d*) 'regulation' means a regulation made under the provisions of this Act.

369. Alcohol without the admixture of any denaturants, and denatured alcohol and specially denatured alcohol as defined in section one of this Part, which is intended for use in the arts and industries or for fuel, light or power, or for any mechanical purpose, may be sold under conditions as hereinafter provided, free from excise duty.

370. Alcohol shall be manufactured, denatured or specially denatured in Canada only in premises thereto licensed.

371. (1) Denatured alcohol shall be sold, delivered and transported without restriction to dealers, manufacturers and other persons.

(2) Specially denatured alcohol shall only be sold or delivered under a special permit to dealers and manufacturers to be used in the arts and industries in cases where denatured alcohol would be unsuitable, and shall only be moved or transported under such conditions as the Minister may by regulations prescribe.

(3) Alcohol without any denaturant may be sold, free of excise duty, and delivered (*a*) for scientific purposes only in such limited quantities as may be prescribed by the Minister, to universities and to scientific and research laboratories approved by the Minister, and (*b*) in limited quantities for the purpose of medical treatment only to public hospitals chiefly maintained by public subscription or endowment, approved by the Minister. In any such cases the alcohol shall only be sold, delivered or transported under such conditions as the Minister, by regulation, may prescribe.

(4) Alcohol without any denaturant shall be sold or delivered, free of excise duty, under such conditions and in quantities as the Minister, by regulations, may prescribe, to specially licensed manufacturers of such products, in the preparation of which pure alcohol is essential as an agent, solvent or precipitant, but in which the finished product contains no alcohol.

(5) No alcohol shall be manufactured or sold under the provisions of this Act for beverage purposes.

372. The recovery of alcohol after it has been used for industrial purposes and its redistillation and purification shall only be done on the premises in which the alcohol was used or at a duly licensed distillery, and all alcohol recovered on the premises aforesaid must be used in the same manufacturing establishment in which it was originally used.

373. (1) All vessels, the capacity of which is one gallon or less, when containing wood alcohol or denatured alcohol, whether in the possession of the manufacturer or other person, shall have affixed thereto a label bearing the words 'Methyl-Hydrate—Poison' in black letters on white ground not less than one-fourth of an inch in height. If the capacity of the package exceeds one gallon, a label shall be affixed thereto bearing the inscription heretofore defined, in black letters on a white ground not less than one-half of an inch in height.

(2) Except as herein otherwise provided, any person who holds in possession, sells, exchanges or delivers any alcohol or specially denatured alcohol contrary to the provisions of this section shall be liable upon summary conviction to a penalty of not less than one hundred dollars and not exceeding five hundred dollars.

374. All the provisions of Part II of this Act respecting bonded manufacturers, licenses and the obligations of persons holding them, the keeping of books or accounts, and the making of returns, so far as applied by regulations, and all provisions respecting penalties, so far as applicable, shall have full force and effect with respect to the manufacture, denaturing, special denaturing and recovery of alcohol, and the persons licensed as herein provided, as if such provisions had been enacted with special reference to the manufacture, denaturing, special denaturing and recovery of alcohol and the issue of licenses for such manufacturers.

APPENDIX L.

CIRCULAR RELATING TO THE ADVISABILITY OF THE INCREASED USE OF FERTILIZERS IN CANADA. ISSUED BY THE HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

"The Honorary Advisory Council for Scientific and Industrial Research has, since its creation in 1916, kept in touch with matters relating to the manufacture of artificial nitrogenous fertilizers such as sodium and ammonium nitrate, cyanamide, ammonium sulphate, etc.

"The Council has, as a result, collected a large amount of information on these subjects and is in a position to gather and tabulate more if conditions in this country appear to warrant this being done.

"It would seem that there should be a considerable field in Canada for the use of fertilizers, and, as in other countries, the demand cannot be adequately filled from natural sources, such as manure, blood, etc., so it will, no doubt, be here, if fertilizers are to be made use of to the extent to which the benefits derivable from them warrant.

"The position regarding the use of nitrogenous fertilizers is not perhaps quite the same as in Europe where the desire to provide adequate supplies of foodstuffs

gives rise to intensive farming. There, most of the available land is already under cultivation and the only way in which greater actual production can be secured is to obtain larger yields per acre. In the Dominion, however, there are two ways of increasing production, viz., (*a*) by increasing the acreage under cultivation; (*b*) by increasing the yield per acre. Because of the comparative smallness of the population and the consequent difficulty of obtaining farm labour, however, the latter method is probably the more desirable as it tends directly to the conservation of labour as manifestly there must be less work involved at all stages from seeding to harvesting, in getting a given yield from one acre of land than in getting the same yield from a larger area.

"In view of the foregoing, the Council is very desirous of ascertaining what are the possibilities in this country for the use of nitrogenous fertilizers on an extended scale, and of learning whether your Department is undertaking, or is prepared to undertake, experiments with artificial nitrogenous fertilizers with the definite object of increasing their use by the farmers.

"There is an aspect of this question which should not be lost sight of as it is of great importance to the country at large.

"Several of the most successful methods of making artificial nitrogenous fertilizers use electric power in considerable quantity and Canada, with her great water-powers, is peculiarly well fitted to supply such power.

"The manufacture of such nitrogenous fertilizers on a large scale would, therefore achieve several results as follows:—

"(*a*) Tend to solve the farm labour problem.

"(*b*) Produce better foodstuffs with less waste.

"(*c*) Enable foreign markets to be supplied with fertilizers from Canada, thus bringing money into the country.

"(*d*) Enable existing large water-powers to be utilized to better advantage by employing off-peak power.

"(*e*) Enable water-powers to be developed in remote districts where otherwise it would not pay to develop them, thus opening up new districts and bringing in new industries, etc., and generally tending to the growth and economic benefit of the country.

"Though no thorough investigation of the subject has yet been made there is reason to believe that where large water-powers have been or are being, developed, there are, in many cases, large quantities of power running to waste through off-peak hours,—power which might well be employed in the manufacture of fertilizers.

"One process of making artificial fertilizers uses only materials which are to be found in very many localities, viz., air and lime; while another uses air, lime, and coke, so that if coke be obtainable in sufficient quantity this latter process could be employed.

"Still another process uses nitrogen obtained from the air and hydrogen which can readily be obtained electrically from water, though there are other means of getting it.

"The Council feels confident that it is in the best interests of the Dominion that the whole of the fundamental questions involved in this matter should be thoroughly investigated, and would be glad to learn that you are in sympathy with their view and that your Department would be willing to co-operate in any possible way in order that a subject of so great importance may be given the attention it deserves."

Available information regarding nitrogen fixation tends to show that it is possible, in Canada, to produce fixed nitrogen in the form of calcium cyanamide more cheaply, possibly, than in any other form.

It is therefore highly desirable to know at an early date whether calcium cyanamide can be used in the soils found in different parts of this country, particularly

rs reports of experiments made in England lead to the conclusion that this substance can be used to greater advantage on some soils than others.

It is understood from experiments recently made in England that the freeing of nitrogen from cyanamide is promoted by the action of certain bacteria and that these bacteria flourish in some soils better than in others. If the experiments in England be confirmed it is desirable that we in this country should ascertain whether our soils are suitable for the development of the requisite bacteria and whether soils which are partly suitable can be improved in this direction.

For this purpose tests should be carried out on Experimental Farms and in connection with the various Agricultural Colleges, as well as elsewhere, to furnish us with definite knowledge on these points and we shall be grateful for co-operation on your part to that end.

APPENDIX M.

LIST OF BRITISH TRADE ASSOCIATIONS FOR RESEARCH.

The following is a list of research associations which have been approved by the Department as complying with the conditions laid down in the government scheme for the encouragement of industrial research and have received licenses from the Board of Trade under section 20 of the Companies' (Consolidated) Act of 1908:—

British Boot, Shoe and Allied Trades Research Association, Technical School, Abington Square, Northampton.
Secretary—Mr. John Blakeman, M.A., M.Sc.

British Cotton Industry Research Association, 108 Deansgate, Manchester.
Secretary—Miss B. Thomas.

British Empire Sugar Research Association, Evelyn House, 62 Oxford Street, London, W. 1.
Secretary—Mr. W. H. Giffard.

British Iron Manufacturers' Research Association, Atlantic Chambers, Brazennose Street, Manchester.
Secretary—Mr. H. S. Knowles.

British Motor and Allied Manufacturers' Research Association, 39 St. James's Street, London, S.W. 1.
Secretary—Mr. Horace Wyatt.

British Photographic Research Association, Sicilian House, Southampton Row, London, W.C. 1.
Secretary—Mr. Arthur C. Brookes.

British Portland Cement Research Association, 6 Lloyd's Avenue, London, E.C. 3.
Secretary—Mr. S. G. S. Panisset, A.C.G.I., F.C.S.

British Research Association for the Woollen and Worsted Industries, Bond Place Chambers, Leeds,
Secretary—Mr. Arnold Frobisher, B. Sc.

British Scientific Instrument Research Association, 26 Russell Square, London, W.C. 1.
Secretary—Mr. J. W. Williamson, B.Sc.

British Rubber and Tyre Manufacturers' Research Association, c/o Messrs. W. B. Peat & Co., 11 Ironmonger Lane, London, E.C. 2.

The Linen Industry Research Association, 3 Bedford Street, Belfast.
Secretary—Miss M. K. E. Allen.

Glass Research Association, 7 Seamore Place, London, W. 1.
Secretary—Mr. E. Quine, B.Sc.

British Cocoa, Chocolate, Sugar Confectionery, and Jam Trades Research Association, 9 Queen Street Place, London, E.C. 4.
Secretary—Mr. R. M. Leonard.

Schemes for the establishment of Research Associations in the following industries have reached an advanced state of development.

RESEARCH ASSOCIATIONS APPROVED BY THE DEPARTMENT BUT NOT YET LICENSED BY THE BOARD OF TRADE.

British Music Industries Research Association.
British Refractory Materials Research Association.
British Non-Ferrous Metals Research Association.
Scottish Shale Oil Research Association.

PROPOSED RESEARCH ASSOCIATIONS WHOSE MEMORANDUM AND ARTICLES OF ASSOCIATION ARE UNDER CONSIDERATION.

British Launderers' Research Association.
British Electrical and Allied Industries Research Association.
British Aircraft Research Association.

INDUSTRIAL ORGANIZATIONS ENGAGED IN PREPARING MEMORANDUM AND ARTICLES OF ASSOCIATION.

Silk Manufacturers.
Leather Trades.
Master Bakers and Confectioners.
Engineering and Shipbuilding.
Pottery.
Lighter Metal Trades (Manufacturing process).

In addition to the industries included above, certain others are engaged in the preliminary consideration for forming Research Associations.

APPENDIX N.

Research Association Circular I (Revised).

THE GOVERNMENT SCHEME FOR INDUSTRIAL RESEARCH.

A FUND OF A MILLION.

The Government, as already announced, have placed a fund of a million sterling at the disposal of the Research Department to enable it to encourage the industries to undertake research. Much will depend upon the way in which this money is spent. The independence and initiative of the British manufacturer have contributed largely

in the past to his success. After the war he will need all possible assistance in undertaking and developing research work as a means of enlarging his output and improving its quality. But if the help is to be effective, it must increase his independence and initiative. It must avoid chaining him to the routine of Government administration, however efficient. It must be so given as to enlist his active support. To the initiative of the manufacturer, the improvement of old and the discovery of new industrial processes in this and other countries have largely been due. It has been the co-operation of progressive industry with science which has led to the practical application of the results obtained in the laboratories of scientific men. The Advisory Council for Scientific and Industrial Research have, therefore, recommended after consultation with manufacturers and others that the new fund should be expended on a co-operative basis in the form of liberal contributions by the Department towards the income raised by voluntary associations of manufacturers established for the purpose of research. By this method the systematic development of research and the co-operation of Science with Industry will be carried out under direct control of the industries themselves. It is also hoped that the co-operation of the firms concerned in any one industry may enable research work to be undertaken which could not have been dealt with by individual firms.

THE NEED OF COMBINATION FOR RESEARCH.

All considerations point to the necessity for combination to this end. If the firms in an industry which are engaged in the production of similar articles or alternatively if the firms in different industries which make use of the same or similar raw or semi-manufactured materials will combine to improve those articles or materials, to discover new processes or to increase the efficiency of existing processes, the Department will contribute liberally to a joint fund for this purpose. The fund for each industry will be expended by a Committee or Board appointed by the contributing firms in that industry, and the results obtained will be available for the benefit of the contributing firms.

The Department realizes that there will be many difficulties in the way. Some industries are large and well organized or their dependence on Science is obvious, while others are either small, badly organized, or are not obviously based on the application of scientific principles. Again, some industries are from their nature mainly interested in research because they are users of certain materials which are susceptible of improvement, and these materials are also used by other industries. Experience has shown that in some cases a Research Association may be established for the whole of a complex industry, whereas in others it is most convenient for only the firms engaged in a single section to combine to form an Association. Generally speaking, it is difficult to combine in a single Association both the makers and the users of any commodity, though there is one instance where the attempt to do so has been successful. It appears to be certain, however, from these considerations that some firms will wish to belong to more than one combination for research purposes, and that if wasteful effort is to be avoided, every possible means must be used to encourage co-operation between different research organizations as well as between the several firms within the same organization.

THE BENEFITS WHICH FIRMS WILL RECEIVE.

But this will not exhaust the problems ahead. Some firms in an industry will be in a better position to make profitable use of the results of research than others. All firms in an industry are not equally alive to the possibility of improvement, and each individual firm has its own views as regards the measure of the advantage to be obtained from research work in its particular branch of industry.

All firms invited to join such an organization as is contemplated are likely to ask themselves what they are going to get out of it. They would not be efficient businesses if they did not. The answer to this question ought to give an outline sketch of the way in which such an industrial research organization would work. The means and method of its establishment will be described in later paragraphs.

It is anticipated that each firm subscribing to a research organization will have the following privileges:—

(1) It will have the right to put technical questions and to have them answered as fully as possible within the scope of the research organization and its allied associations.

(2) It will have the right to recommend specific subjects for research, and if the Committee or Board of the research organization of that industry consider the recommendation of sufficient general interest and importance, the research will be carried out without further cost to the firm making the recommendation, and the results will be available to all the firms in the organization.

(3) It will have the right to the use of any patents or secret processes resulting from all researches undertaken either without payment for licenses, or at any rate on only nominal payment as compared with firms outside the organization.

(4) It will have the right to ask for a specific piece of research to be undertaken for its sole benefit at cost price, and, if the governing Committee or Board approve, the research will be undertaken.

It will be realized that no firm outside the organization will have any of these rights. The documents and bulletins available for members of the organization will not be published unless the controlling committee of the organization decide that they shall be.

BUREAU OF INFORMATION.

There are other privileges to which each firm subscribing to a Research Association will be entitled if the Association decides, as several Associations have already done, to establish a Bureau of Information. Every one who has had experience in research is fully aware of the fact that useful discoveries usually take time to reach the stage at which they are available for commercial use. If for no other reason than this it will often be desirable for a Research Association to set up a Bureau of Information which will give to each of its members technical information relating to the industry. If this is done each firm will have the following privileges:—

(1) It will receive a regular service of summarized technical information which will keep it abreast of the technical developments in the industry at home and abroad. To do as much for itself any firm would have to employ more than one man on its staff reading and translating the technical press.

(2) It will be able to obtain a translated copy of any foreign article in which it may be specially interested and to which its attention will have been drawn by the periodical bulletin.

SUBSCRIPTION FROM THE INDUSTRY.

The method of assessing the subscription of each firm will have to be determined in negotiation with each industry or section of an industry which may agree to combine for the purposes of research, but the intention is that firms should contribute on a basis proportionate to their size. Thus the small firm will contribute less than the large firm, yet it will have the same privileges, though as a rule it will not in the

nature of the case have the same facilities for exploiting the results of research. On the other hand the small firm will be more likely to use the benefits offered under heads (1) and (4) than the large firm.*

APPROVED RESEARCH ASSOCIATIONS.

The Department is advised that the best machinery for the purpose in view is the establishment of Research companies limited by guarantee of a nominal sum (*e.g.* £1) and working without profit, *i.e.*, without the division of profits among the members in the form of dividends. In order to assist industries in the formation of limited companies or associations of this kind, the Research Department has drafted a specimen Memorandum and Articles of Association† based upon the skeleton prepared by the Board of Trade for use in such cases. It is not intended to impose this specimen Memorandum and Articles of Association on industries desiring to establish Research Associations. The order in which the objects of the Association are set out may need modification to suit varying circumstances, and the "objects" themselves may have to be varied by either excision or enlargement, but the intention of the draft has been to include, as far as could be foreseen, all those powers and activities which an Association founded for the purposes of research might need to possess. At the same time, the nearer any draft Memorandum and Articles of Association can be brought to the specimen, the quicker will be the departmental procedure and the smaller the legal costs.

REMISSION OF INCOME TAX.

Such Associations, being limited liability companies working without profits, will be able to distribute beneficial information to their members without infringing Section 20 of the Companies' Acts; and if they are established in accordance with the provisions referred to, the subscriptions paid to them by contributing firms will, under a recent decision of the Board of Inland Revenue, be recognized by the surveyors of taxes as business costs of the firms and will not be subject to income or excess profits taxes. The income of the Associations will similarly be free of income tax.

GOVERNMENT GRANTS.

Any such Association will also be qualified to apply for grants towards its income from the Research Department under stated conditions,‡ though experience has shown that not all industries will wish to do so. In those cases where aid is necessary a Government grant will be given for a period of years to be agreed upon, not exceeding five, though it may be extended if funds are available and the condition of the industry calls for further aid. The contribution will be made in the anticipation that when the new organizations are once fairly launched on their career the need for direct State assistance will disappear and British industry will be as self-sufficing in the field of industrial research as it has proved itself to be in other spheres of work.

OWNERSHIP OF THE RESULTS OF INVESTIGATION.

The whole of the results of researches conducted by any Research Association will belong to the Association itself, which will hold them in trust for the benefit of its members. The Government is, however, specially bound to safeguard the national interests where new discoveries are made with the assistance of Parliamentary funds,

* The "Method of Subscription to Research Associations" is described in "*Research Association Circular 4*".

† Draft Memorandum and Articles of Association for Trade Associations for Research ("*Research Association 2*").

‡ See "*Research Association 3.*"

and accordingly, besides the powers it already possesses under the Patents and Designs Act, 1907, it will keep in its own hands two additional powers, which may be said to limit the absolute ownership otherwise reserved to the Association—the right of veto in case any proposal is made by a Research Association to communicate any results of research to a foreign person or to a foreign corporation, and the right, after consultation with the Association concerned, of communicating the results of discoveries to other industries for their use on suitable terms. The Department will not, however, make any results obtained by a Research Association available to firms or individuals who are eligible for membership of that Association but have not joined it.

DELEGATION OF RESPONSIBILITY TO ASSOCIATIONS.

It will be seen from this short description and from a detailed study of these documents that the policy of the Research Department is to delegate the prosecution of industrial research on a co-operative basis to the industries themselves, working through voluntary associations of firms engaged in producing similar articles, or using the same materials. It is hoped and anticipated that these Associations will co-operate with each other in the solution of problems of common interest, and the Department intends to do its utmost to encourage such alliances. It is also anticipated that the Associations will make every possible use of existing facilities for scientific research whether at the Universities and Technical Colleges, or at such central institutions as the National Physical Laboratory. There will be ample scope for all these agencies as well as for any special research institutes which the Research Associations may establish in future for their own purposes.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH,
GREAT GEORGE STREET, WESTMINSTER, S.W.1.
December, 1918.

Research Association Circular 2. (Revised.)

DRAFT MEMORANDUM AND ARTICLES OF ASSOCIATION.

The following draft memorandum and Articles of Association are suggested for adoption by the promoters of Research Associations to be established under the Government Scheme for Industrial Research described in "Research Association 1," issued by the Department of Scientific and Industrial Research, with such modifications as the circumstances of each industry may require.

When the draft Memorandum and Articles of the proposed Research Association have been approved by the Department, they must be forwarded in duplicate to the Board of Trade with an application for a license under Section 20 of the Companies (Consolidation) Act of 1908, to enable the promoters to register the Association without the addition of the word "Limited." The application should also state the names of the persons who will sign the Memorandum and of the persons who will form the first Council of the Association, and should enclose a cheque for £5 10s. for Counsel's fees.

The Companies Acts 1908 to 1917.

COMPANY LIMITED BY GUARANTEE AND NOT HAVING A CAPITAL DIVIDED INTO SHARES.

MEMORANDUM OF ASSOCIATION OF THE BRITISH RESEARCH ASSOCIATION.

1. The name of the Association is the "The British Research Association."

2. The registered office of the Association will be situate in England.

3. The objects for which the Association is established are:—

(*a*) To promote research and other scientific work in connection with the trade or industry and other trades and industries allied therewith or accessory thereto, and for that purpose to establish, form, equip and maintain laboratories, workshops or factories, and conduct and carry on experiments, and to provide funds for such work, and for payment to any person or persons engaged in research work, whether in such laboratories or elsewhere, and to encourage and improve the education of persons who are engaged or are likely to be engaged in the industry.

(*b*) To prepare, edit, print, publish, issue, acquire and circulate books, papers, periodicals, gazettes, circulars and other literary undertakings treating of or bearing upon the said trades or industries or any of them and to establish, form and maintain museums, collections, libraries and collections of literature, statistics, scientific data and other information relating to the said trades or industries or any of them or to matters of interest to the members thereof, and to translate, compile, collect, publish, lend and sell, and endeavour to secure, or contribute to, the translation, compilation, collection and publication, by Parliament, Government Departments and other bodies or persons, of any such literature, statistics and information, and to disseminate the same by means of the reading of papers, delivery of lectures, giving of advice, the appointment of advisory officers or otherwise.

(c) To retain or employ skilled, professional or technical advisers or workers in connection with the objects of the Association, and to pay therefor such fees or remuneration as may be thought expedient, also to found, aid, maintain and endow scholarships and bursaries for the remuneration, instruction and support of students in research work, or persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, whether in the laboratories of the Association or elsewhere, and to employ and remunerate as may be expedient, instructors and supervisors for such students and also for persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, paying due regard to the provision of instruction by existing institutions.

(*d*) To encourage the discovery of, and investigate and make known the nature and merits of inventions, improvements, processes, materials and designs which may seem capable of being used by Members of the Association for any of the purposes of the said trades or industries or any of them and to acquire any patents or licenses relating to any such inventions, improvements or processes, and to acquire and register any designs or standardization marks, whether for general or special purposes, with a view to the use thereof by Members of the Association and others upon such terms as may seem expedient, and to develop, perfect and test the value of such inventions, improvements, processes and designs by manufacturing, exhibiting and placing on the market any article or substances to which the same may be capable of application.

(*e*) To apply to the Government, public bodies, Urban, Local, Municipal, County and other bodies, corporations, companies or persons for, and to accept grants of money and (subject to section 19 of the Companies (Consolidation) Act, 1908) of land, donations, gifts, subscriptions and other assistance with a view to promoting the objects of the Association, and to discuss and negotiate with the Committee of the Privy Council for Scientific and Industrial Research and other Government Departments, public and other bodies, corporations, companies or persons, schemes of research and other work and matters within the objects of the Association and to conform to any proper conditions upon which such grants and other payments may be made.

(*f*) To establish, promote, co-operate with, become a member of, act as, or appoint trustees, agents or delegates for, control, manage, superintend, afford financial assistance to, or otherwise assist the research work of any associations and institutions and other bodies incorporated or not incorporated, whose objects include scientific or industrial research.

(*g*) To establish, maintain, control and manage branches of the Association in the United Kingdom and elsewhere as may seem expedient, and from time to time to determine the constitution, rights, privileges, obligations and duties of such branches, and, when thought fit, to dissolve and modify the same.

(*h*) To undertake and execute any trusts which may be conducive to any of the objects of the Association.

(*i*) To carry out any of the above-mentioned research or other scientific work, and to do all or any of the above-mentioned things whether affecting the whole of the said trades or industries or merely one or more particular parts or sections of the said trades or industries or any of them or the business of any particular member or group of members of the Association, and, in the case of work not affecting the whole of the said trades or industries, to make such arrangements as to special payment by such particular sections or members or groups of members as may be expedient.

(*j*) To borrow or raise any money that may be required by the Association upon such terms as may be deemed advisable, and in particular by the issue of bonds, debentures, bills of exchange, promissory notes or other obligations or securities of the Association, or by mortgage or charge of all or any part of the property of the Association.

(*k*) To draw, make, accept, indorse, discount, execute and issue promissory notes, bills of exchange and other negotiable or transferable instruments.

(*l*) To invest the moneys of the Association not immediately required in any one or more of the modes of investment for the time being authorized by law for the investment of trust moneys and in such manner as may from time to time be determined.

(*m*) Subject to the provisions of the 19th Section of the Companies (Consolidation) Act, 1908, to purchase, take on lease or in exchange, hire or otherwise acquire any real and personal property, and in particular any land, buildings, workshops, factories, laboratories, machinery, plant, apparatus, appliances and any rights or privileges necessary or convenient for the purposes of the Association, and to construct, erect, alter, improve and maintain any buildings which may be from time to time required for the purposes of the Association, and to manage, develop, sell, demise, let, mortgage, dispose of, turn to account or otherwise deal with all or part of the same with a view to the promotion of the objects of the Association.

(*n*) To pay all expenses, preliminary or incidental to the formation of the Association and its registration.

(*o*) To use the funds of the Association in the employment of persons of learning or skill, and the provision and use of buildings, and of instruments, materials and appliances, and of any of the equipment of the Association for any form of scientific studies which may be considered to have some bearing, whether immediate or ultimate, on practical problems involved in the nature or use of

(*p*) To collect, arrange, index and publish information as to materials, patents, processes, machines, appliances and tools used or known in or in regard to or the said trades or industries or likely to be useful thereto, and to establish and maintain a Bureau of Information for the benefit of members of the Association.

(q) To establish and support or aid in the establishment and support of Associations, institutions, funds, trusts and conveniences calculated to benefit employees or ex-employees of the Association or the dependents or connections of such persons, and to grant pensions and allowances to and to make payments towards insurance of such persons.

(r) To procure the Association to be registered or recognized in any part of the British Empire or in any foreign country or place.

(s) To do all such other lawful things as may be incidental to or conducive to the attainment of the above objects.

Provided always that nothing herein contained shall empower the Association to carry on the business of life insurance, personal accident assurance, fire insurance or employers' liability insurance or the business of insurance within the meaning of the Assurance Companies Act, 1909, Section 1.

Provided also that the Association shall not support with its funds any object, or endeavour to impose on or procure to be observed by its Members or others any regulation, restriction, or condition, which, if an object of the Association, would make it a trade union.

Provided also that in case the Association shall take or hold any property subject to the jurisdiction of the Charity Commissioners or Board of Education for England and Wales, or any authority exercising corresponding jurisdiction outside England and Wales, the Association shall not sell, mortgage, charge or lease the same without such authority, approval or consent as may be required by law, and as regards any such property the Managers or Trustees of the Association shall be chargeable for such property as may come into their hands and shall be answerable and accountable for their own acts, receipts, neglects and defaults, and for the due administration of such property in the same manner and to the same extent as they would as such Managers or Trustees have been if no corporation had been effected, and the incorporation of the Association shall not diminish or impair any control or authority exerciseable by the Chancery Division, the Charity Commissioners, or the Board of Education or any such other authority as aforesaid over such Managers or Trustees, but they shall, as regards any such property, be subject jointly and separately to such control or authority as if the Association were not incorporated. In case the Association shall take or hold any property which may be subject to any trusts, the Association shall only deal with the same in such manner as allowed by law having regard to such trusts.

4. The income and property of the Association, whencesoever derived, shall be applied solely towards the promotion of the objects of the Association as set forth in this Memorandum of Association, and no portion thereof shall be paid or transferred directly or indirectly, by way of dividend, gift, division, bonus or otherwise howsoever by way of profit, to the Members of the Association.

Provided that nothing herein shall prevent the payment in good faith of reasonable and proper remuneration to any officer or servant of the Association or to any member of the Association, in return for any services actually rendered to the Association, or for any material, labour, plant or power supplied for experimental purposes, nor prevent the payment of interest at a rate not exceeding six per centum per annum on money lent, or payment of a reasonable and proper rent for premises demised or let by any Member of the Association, but so that no Member of the Council or Governing Body of the Association shall be appointed to any salaried office of the Association or any office of the Association paid by fees, and that no remuneration or other benefit in money or money's worth shall be given by the Association to any Member of such Council or Governing Body except by way of repayment of out-of-pocket expenses and interest at the rate aforesaid on money lent or the payment of a reasonable and proper rent for premises demised or let to the Association (or any remuneration to any member of the Council in accordance with any recommendation

by or with the approval of the Committee of the Privy Council for Scientific and Industrial Research), provided that nothing hereinbefore contained shall prevent any payment to any Railway, Gas, Electric Lighting, Water, Cable or Telephone Company of which a member of the Council may be a member, or to any corporate body of which a member of the Council may be a member or shareholder holding less than one-hundredth part of its capital or to any other corporate body or to any firm with the previous consent of the Committee of the Privy Council for Scientific and Industrial Research, and Members shall not be bound to account for any share of profits they may receive in respect of any such payment.

Provided also that nothing herein shall prevent any Member of the Association, whether a member of the Council or not, from exercising any processes and making, using, acquiring and vending any articles and things in the ordinary course of his business for profit or otherwise under any license or permission in respect of any discovery, invention and patents resulting from the work of the Association.

5. No addition, alteration or amendment shall be made to or in the regulations contained in the Articles of Association for the time being in force, unless the same shall have been previously submitted to and approved by the Board of Trade in consultation with the Committee of the Privy Council for Scientific and Industrial Research.

6. The fourth and fifth paragraphs of this Memorandum contain conditions on which a license is granted by the Board of Trade to the Association in pursuance of Section 20 of the Companies (Consolidation) Act, 1908.

7. The liability of the members is limited.

8. Every Member of the Association undertakes to contribute to the assets of the Association, in the event of the same being wound up during the time that he is a Member, or within one year afterwards, for payment of the debts and liabilities of the Association contracted before the time at which he ceases to be a Member, and of the costs, charges and expenses of winding up the same, and for the adjustment of the rights of the contributories amongst themselves, such amount as may be required not exceeding £5.

9. If upon the winding up or dissolution of the Association there remains, after the satisfaction of all its debts and liabilities, any property whatsoever, the same shall not be paid to or distributed among the Members of the Association, but shall be given or transferred to some other institution or institutions having objects similar to the objects of the Association, and which shall prohibit the distribution of its or their income and property amongst its or their Members to an extent at least as great as is imposed on the Association under or by virtue of Clause 4 hereof, such institution or institutions to be determined by the Members of the Association, subject to the approval of the Committee of the Privy Council for Scientific and Industrial Research at or before the time of dissolution, or in default thereof by such Judge of the High Court of Justice as may have or acquire jurisdiction in the matter, and if and so far as effect cannot be given to the aforesaid provision, then to some charitable object.

10. True accounts shall be kept of the sums of money received and expended by the Association, and the matters in respect of which such receipts and expenditure take place, and of the property credits and liabilities of the Association, and, subject to any reasonable restrictions as to the time and manner of inspecting the same that may be imposed in accordance with the regulations of the Association for the time being, shall be open to the inspection of the Members. Once at least in every year the accounts of the Association shall be examined, and the correctness of the balance sheet ascertained by one or more properly qualified auditor or auditors.

WE, the several persons whose names and addresses are subscribed, are desirous of being formed into an Association in pursuance of this Memorandum of Association.

Names, Addresses, and Descriptions of Subscribers.

Dated the day of , 19

The Companies Acts, 1908 to 1917.

COMPANY LIMITED BY GUARANTEE AND NOT HAVING A CAPITAL DIVIDED INTO SHARES.

ARTICLES OF ASSOCIATION OF THE BRITISH RESEARCH ASSOCIATION.

1. In the construction of these presents the following words and expressions shall have the following meanings respectively unless there be something in the subject matter or context repugnant thereto.

"The Companies Acts" means the Companies Acts 1908 to 1917 and every other Act incorporated therewith or any Act or Acts of Parliament amending the same.

"Month" means calendar month.

"The Association" means the British Research Association.

"The Office" means the registered office of the Association.

"The Council" until the election of the first Council means the Signatories, and thereafter means the Council of Management of the Association as a body or a quorum of the members thereof at a Council meeting.

"Secretary" includes any person appointed to perform the duties of Secretary temporarily.

"In Writing" and "Written" include printing, lithography, and typewriting and all other modes of representing or reproducing words in visible form.

Words which have a special meaning assigned to them in the Companies Acts have the same meaning in these presents.

Words importing the singular number include the plural, and the converse applies.

Words importing males include females.

Words importing persons include corporations.

"Notice" includes all written communications to members.

"These presents" means the Articles of Association for the time being of the Association.

"The Department" means the Committee of the Privy Council for Scientific and Industrial Research.

Members.

2. For the purpose of registration the number of Members of the Association is declared to be , but the Council may register an increase in the number of members whenever and as often as they think fit.

3. The Association is established for the purposes expressed in the Memorandum of Association.

4. The subscribers hereto shall be the first Ordinary Members, and subject as hereinafter mentioned it shall rest with the Council to determine the terms and conditions on which subsequent Members shall from time to time be admitted.

5. The membership of the Association shall consist of persons and corporate bodies with the following status:—

(*a*) Ordinary members who shall be the signatories of the Memorandum of Association and those British subjects carrying on business in the production or marketing of or in the production of machinery, appliances, accessories or materials to be employed in the production or marketing of and those British Corporations carrying on business as aforesaid who shall be elected as Members of the Association in manner hereinafter provided.

(*b*) Associate Members who must be scientific workers, pressmen and others connected with the said trades or industries or any of them, or likely to assist in the development of the said trades or industries or any of them, or persons or incorporated companies dealing in requisites used in the said trades or industries or any of them in any part of the world, or superintendents, directors, secretaries or other officers of limited liability companies carrying on any of such businesses.

(*c*) Delegate Members, being delegates of other associations established for kindred purposes.

(*d*) Honorary Members, being persons whether entitled or not to become Members under the above provisions and nominated for membership by the Council for special services or for special cause, and elected at a General Meeting.

No Member, other than an Ordinary Member or the representative for the time being of an Ordinary Member under Articles 7-10 inclusive, or any of them, shall be entitled to vote at General Meetings. Members other than Ordinary Members shall be entitled to such of the privileges and benefits of the Association as the Council may from time to time determine, but without power to vote at any General Meeting.

Provided always that an Ordinary or Associate Member must be a British subject or a corporate body registered in Great Britain or Ireland or obtaining its Charter from the Government of these countries and in all cases where capital is divided into shares having three-fourths of the issued capital owned by British subjects in their own right entitling the holders thereof to not less than three-quarters of the voting power of the Company provided also that any member ceasing to fulfil the requisite conditions of membership shall *ipso facto* cease to be a member.

6. The following provisions shall have effect with respect to the Association, and in case of any conflict between the provisions of this Article and those of any other Article the provisions of this Article shall prevail:—

A. Every application for membership of the Association shall be accompanied by:—

(1) In the case of an application made by an individual, a declaration by the applicant stating whether he is or is not a British subject, and whether he has or has not ever taken an oath of allegiance or otherwise become a citizen or subject of any, and if so, what, enemy or foreign sovereign or State; and, if a British subject, whether he is a natural-born British subject, or a British subject by naturalization or otherwise, and, if naturalized, whether he remains for any purpose in the allegiance of any, and if so, what, enemy or foreign sovereign or State.

(2) In the case of an application made by a corporation, a declaration made on behalf of the corporation by the secretary or other officer authorized in that behalf stating whether the corporation is an enemy or foreign corporation or a corporation under foreign control.

And in either case the Council may, before electing any Member, require such further evidence as it shall in its absolute discretion think necessary in support of any such declaration.

B. In the event of its being proved to the satisfaction of the Council that the declaration to be made under Clause A. is untrue, the Council shall by resolution (which shall be final and conclusive and not subject to question by any person on any ground whatever) exclude such Member from membership, and upon such resolution being

passed such Member shall cease to have any interest in the Association and shall have no claim against the Association or the Council or any of its members in respect thereof.

C. The Council shall not without the consent of the Board of Trade elect to membership any foreigner or foreign corporation or corporation under foreign control.

D. If at any time a Member shall cease to be a British subject or shall come in any way directly or indirectly under the control or directions of, or become in the opinion of the Board of Trade subject to the influence of any foreign State, body, person or corporation, or corporation under foreign control, the Council may at any time and shall at the request of the Board of Trade serve on the Member in question a notice in writing requiring such Member to retire from the Company, and upon such notice being given, such Member shall *ipso facto* cease to be a Member of the Association, and shall not be eligible for re-election as a Member.

E. In the event of any Member ceasing to be a British subject or coming in any way directly or indirectly under the control or directions of any foreign State, body, person or corporation, or corporation under foreign control, he shall within thirty days disclose the fact to the Council, and failure to make such a disclosure within such period shall render the Member liable to exclusion in the manner provided by Clause F hereof. Provided that no such right of exclusion under this Article shall be exercised by the Council without the consent of the Board of Trade.

F. No person other than a British subject resident in the United Kingdom shall be qualified to be a member of the Council, and the office of a Member of the Council shall be vacated:—

(*a*) If he cease to be a British subject, or cease to reside in the United Kingdom.

(*b*) If he be called upon in writing by at least three-fourths of all the other Members of the Council for the time being to resign office on the ground that he is, in their opinion, subject to the influence of a foreign State, body, person, or corporation, or a corporation under foreign control, and for that reason is not a desirable person to be a Member of the Council, and so that the opinion of a three-fourths majority of the other Members of the Council so expressed shall not be subject to question by any person or corporation on any ground whatsoever.

G. In these provisions:—

The expression "foreigner" means every person who is not a British subject.

The expression "foreign corporation" means any corporation which is not incorporated in and under the laws of and has not its principal place of business in some part of the British Empire.

The expression "corporation under foreign control" means:—

(*a*) A corporation of which the majority of Directors or persons occupying the position of Directors, by whatever name called, are foreigners.

(*b*) A corporation members of which holding shares or stock conferring a majority of the votes are foreigners or foreign corporations or persons who hold such shares or stock directly or indirectly on behalf or under the control or directions of foreigners, a foreign State or foreign corporations.

(*c*) A corporation which is by any other means, whether of a like or of a different character, in fact under the control of foreigners, a foreign State or foreign corporations.

(*d*) A corporation whereof the executive is a corporation within (*a*), (*b*) or (*c*).

The expression "shares" shall include any securities which carry any power of voting with respect to the management of a company, and the expression "shareholder" shall have a corresponding meaning.

H. For the purposes of the foregoing provisions, service of a notice shall be deemed to be effected by sending by registered post a prepaid letter containing the notice and addressed to the Member at his registered address, and service shall be deemed to have been effected at the time at which the letter would have been delivered in the ordinary course of post.

7. No firm or other unincorporated association may as such become a member of the Association, but if any such firm or association should desire to obtain the advantages of membership it shall nominate one of its members to act as its representative, apply in its name for membership and sign the application as its representative and exercise the rights of membership on its behalf. Every person so applying for membership shall be subject to the same rules and regulations concerning elections and otherwise as any person not so nominated, and shall, if elected, have the same rights and be subject to the same liabilities and incidents as any person not so nominated, subject, however, to the provisions of Article 8. The firm or other unincorporated association shall deposit with the Council the nomination of such applicant for membership and shall give all information that may be reasonably required by the Council regarding such applicant.

8. A firm or other unincorporated association which has nominated as its representative one of its members as aforesaid may from time to time revoke the nomination of such member, and subject to the consent of the Council of the Association, nominate another representative in his place. Upon receipt by the Council of any such revocation such member shall *ipso facto* cease to act or be entitled or recognized as a representative of such firm or association, and any person nominated in his place shall, if duly approved by the Council, be and become the representative of such firm or association in the place of the representative whose nomination has been revoked as aforesaid.

9. All revocations and nominations mentioned in Articles 7 and 8 shall be in writing signed by all the members of the firm or other unincorporated association. Each such firm or other unincorporated association shall at the date of each nomination give to the Council in writing full particulars of the nature of the firm or association and its places of business, and of the names, nationality and private address of each partner or member thereof and all such further particulars as the Council shall require, and thereafter shall give such particulars when and as often as may be required by the Council. Any change in the constitution or nature of such firm or association or in the status of any of its members shall be immediately notified in writing to the Council, who if they do not approve such change shall be entitled (without prejudice to Article 16) to give notice in writing to the member representing such firm or association to terminate his membership and to withdraw from the association, and shall at the same time return a due proportion of such member's subscription having regard to the unexpired period for which it is paid, and thereupon such representative shall cease to act or be entitled or recognized as a member and such firm or other unincorporated association as aforesaid shall have no further right to nominate a member to act as its representative.

10. A corporation being a Member shall nominate a person to act as its representative subject to the approval of the Council, and for the purpose of such approval shall give all information that may be reasonably required by the Council. Such representative when so approved shall have the right on behalf of the corporation (and to the extent only to which the corporation would if a person be entitled to do so) to attend meetings of the Association and to vote thereat, and generally exercise all rights of membership on behalf of the corporation. A corporation may from time to time revoke the nomination of such representative, and (subject to the previous consent of the Council of the Association) nominate another representative in his place. All such nominations and revocations shall be in writing under the seal of the corporation. The Council may in its absolute discretion withdraw at any time

its approval of the nominee of a corporation and shall notify the corporation of such withdrawal, whereupon the corporation shall nominate another representative. Provided always that any director or secretary of a corporation which is a Member or any partner in a firm which shall have nominated a representative as hereinbefore provided may attend any meeting of the Association without any right of voting thereat, but the Members present at any meeting may exclude persons who are not Members from such meeting by a resolution passed by a majority of the Members present and entitled to vote and no special notice shall be required before the consideration of such resolution.

11. No person or corporation shall be admitted to Membership of the Association unless an application for membership shall have been signed by him or it or on his or its behalf setting out the particulars required by Article 6.

12. Subject and without prejudice to Article 6 the Council shall in all cases have absolute discretion in deciding whether any person or corporation shall or shall not be admitted to membership of the Association.

13. Any ordinary Member may withdraw from the Association by giving notice in writing duly signed to the Secretary at least six calendar months before the expiration of any financial year, and on paying with such notice any unpaid subscription for the current year, and also for each and any subsequent year which such Member shall have guaranteed to subscribe on election, and thereupon such Member shall be deemed to have ceased to be a Member from the date of the expiration of such financial year. In default of such notice being so given, an ordinary Member shall be liable to pay the subscription for the ensuing year and in cases where any undertaking or guarantee has been given for subscriptions or donations for any given number of years the Member shall continue to be liable thereunder.

14. Any Member other than an ordinary Member may withdraw from the Association by giving notice in writing to the Secretary at any time and paying with such notice any unpaid subscriptions that may be due, and also subscriptions for subsequent years and donations agreed upon or guaranteed by such Member on election (if any) and thereupon shall cease to be a Member.

15. Upon the retirement of any Member by notice as stated in Articles 13 and 14, the Member shall not be entitled under any conditions to any repayment of any subscription or any part thereof whether paid for the current year or for a year or years in advance.

16. Any Member may be moved from the Association by a resolution of the Council passed by a majority of at least three-fourths of the Members present and voting at a special Council meeting of which not less than twenty-one days' previous notice specifying the intention to propose such resolution shall have been sent to the Member whose removal is in question and to all the Members of the Council. Notice of the general nature of the grounds on which such resolution is proposed shall be sent to the Member whose removal is in question at least fourteen days before the meeting, and he shall be entitled to be heard by the Council at the meeting. On a Member being removed, the Council shall return the due proportion of such Member's current subscription having regard to the unexpired period for which it is paid. Provided that in the case of a Member who has been appointed by the Department to be a Member of the Council, the Council shall not take action under this Article without previous consultation with the Department.

17. The rights of any Member shall be personal and shall not be transferable and shall cease upon the Member failing to pay the annual subscription within three months of its becoming due, or in the case of a person on his becoming lunatic or of unsound mind or in any case on the Member ceasing to retain the qualifications on the ground of which the Member was admitted to membership. Nothing herein contained shall prejudice the rights of the Association to claim payment of the full

amount of the subscriptions which the Member shall have undertaken to pay or (subject to Article 6D) prevent the Member from again becoming eligible for membership.

18. Any Member of the Association who shall consider that his or its personal interests may be prejudicially affected by any research proposed to be undertaken by the Association may appeal to the Department against the particular work objected to and shall set forth in the appeal the grounds of the objection and shall at the same time forward a copy of the appeal respectively to the Secretary of the Association and the Director of Research or other responsible technical officer of the Association. The Department shall determine all questions raised on such appeal and its decision shall be final. Provided always that the Department may at any time give special permission or directions to the Director of Research through the Council to proceed with the research notwithstanding any appeal either during the time the appeal is pending or subsequently.

Duties of Members.

19. Every Member of the Association shall be bound:

(*a*) To pay to the Association such entrance fee (if any) and such annual subscription as shall from time to time be fixed by the Association in General Meeting.* Provided always that subscribers shall as a condition attached to membership agree in writing to continue to pay the said subscriptions whether Members or not and in a manner to bind their estates and assets for a period of years from the date of their election. Honorary and Delegate Members shall not be called upon to pay any subscriptions. All payments shall be made at the times in the manner and subject to the conditions set out in the By-laws of the Association in force at the date of such payments.

(*b*) To observe the provisions of these presents and of the Memorandum of Association and all the by-laws, rules and regulations of the Association for the time being in force.

(*c*) To pay and make good to the Association any loss or damage which the Association may sustain through any wilful act or default of such Member or any representative of such Member, but only if such act or default shall be a breach of any provisions of these presents or of the Memorandum of Association or of any by-law, rule or regulation of the Association.

Council of the Association.

20. The business of the Association shall be managed by a Council.

21. The Council shall consist of not more than and not less than Members, unless and until otherwise determined by the Association in General Meeting.

22. All Members of the Council shall save as herein otherwise provided be Ordinary Members of the Association elected by the Association. The Council may co-opt not more than Members of Council who need not be Members of the Association, and need not qualify for membership of the Council by subscription, donation or otherwise. Provided always that the number of such co-opted Members shall never be more than of the whole body of the Members of Council exclusive of those nominated and appointed by the Department.

*NOTE.—The amount of the subscription may be entered here or in separate Articles under a fresh heading if need be. If desired a differentiated basis can be adopted, such as an assessment based on capital, output, wages paid, etc., as discussed in "Research Association No. 4," issued by the Department, with or without proportionate voting rights in accordance with such assessment, and with corresponding provisions for the ascertainment of the capital, output, etc., and other suitable clauses. The power to fix the subscription to be paid by Associate Members is given by this Article, but such subscription will usually be different from that assessed on Ordinary Members and will not be assessed for a period of years.

23. The first Council shall consist of the following persons:—
The persons appointed Members of the Council by this Article and any person appointed under Article 30 to fill casual vacancies among them are for the purpose of these presents to be deemed to be elected Members of the Council.

24. The Association in General Meeting may appoint one President and such number of Vice-Presidents of the Association as they may deem advisable. Such President and Vice-Presidents shall be entitled to attend meetings of the Council and of the Association, but shall have no right to vote as such at any such meetings. The President and Vice-Presidents for the time being shall retire at each Ordinary General Meeting of the Association but shall be eligible for re-election. It shall not be necessary for any President or Vice-President to have any special qualification for office, either by way of subscription, donation or otherwise.

25. Subject to Articles 22, 23, and 26, Members of the Council shall be elected by the Association in General Meeting and shall retire as provided by Article 28.

26. The Department may, on the invitation of the Council, and if the Association is in receipt of a grant from the Department shall have the right to, nominate and appoint not more than persons (whether Members of the Association or not) as additional Members of the Council whatever the number of the Council may be, and may remove from time to time one or more of such additional Members and in that event or in the event of any casual vacancy among such additional members of the Council may appoint others in their place. Provided always that the Department shall not be bound to exercise the said right. All nominations, appointments and revocations under this Article shall be made in writing addressed to the Secretary of the Association and every Member of the Council so nominated and appointed shall continue to act as a Member of the Council until withdrawn by the Department.

27. Notwithstanding the provisions aforesaid a nominated Member shall cease to be a Member of the Council in any of the events mentioned in Article 29.

28. At the Annual General Meeting in the year 1919 and at the Annual General Meeting in each subsequent year one-third of the elected Members of the Council shall retire or if their number is not a multiple of three then the number nearest to one-third shall retire. The Members of Council to retire in every year shall be those who have been longest in office since their last election but as between persons who become Members of Council on the same day those to retire shall (unless they otherwise agree amongst themselves) be determined by lot. All elected Members so retiring shall be deemed to be eligible for re-election.

29. The office of a Member of the Council shall *ipso facto* be vacated:—

(*a*) If he becomes bankrupt or suspends payment or compounds with his creditors.

(*b*) If he is found lunatic or becomes of unsound mind.

(*c*) If by notice in writing to the Council he resigns his office.

30. Subject as aforesaid the Council shall be entitled to appoint a person as a Member of the Council to fill a casual vacancy, howsoever caused. The person so appointed shall hold office until the Annual General Meeting next after his appointment, but he shall then be eligible for re-election.

31. No act or resolution of the Council shall be invalidated by reason of the existence of any vacancy or vacancies among Members of the Council, but if the number of the Members of the Council shall be reduced to less than the continuing Members may act for the purpose only of filling vacancies in the elected Members or summoning a General Meeting of the Association.

Powers of the Council of the Association.

32. The Council shall have sole control in regard to all matters relating to the management and organization of the Association. In addition to the powers and

authorities by these presents or otherwise expressly conferred upon them, they may exercise all such powers and do all such acts and things as may be exercised or done by the Association and are not hereby or by statute expressly directed or required to be exercised or done by the Association in General Meeting, but subject nevertheless to the provisions of any Acts of Parliament for the time being in force and of these presents.

33. Without prejudice to the general powers conferred by the last preceding clause and the other powers conferred by these presents, it is hereby expressly declared that the Council shall have the following powers, that is to say:—

(*a*) To make and impose, vary and repeal by-laws, rules and regulations for the administration and government of the Association and for carrying its objects into effect. Provided always that the same shall not in any way affect, vary or alter the provisions contained in these Articles of Association.

(*b*) To agree and pay the costs, charges and expenses preliminary and incidental to the promotion, formation, establishment and registration of the Association and the preparation, adoption and registration of the Association's Memorandum of Association and of these presents.

(*c*) To pay all expenses incurred in carrying out the objects of the Association.

(*d*) To purchase or otherwise acquire for the Association any property, rights or privileges which the Association is authorized to acquire at such price, and generally on such terms and conditions as they think fit.

(*e*) To secure the fulfilment of any contracts or engagements entered into by the Association by mortgage or charge of all or any of the property of the Association, or in such manner as they may think fit.

(*f*) To take offices or acquire premises for the use of the Association, and to appoint and at their discretion remove or suspend such managers, secretaries, officers, clerks, agents and servants, whether engaged for permanent, temporary or special services, and to determine their powers and duties and fix their salaries or emoluments and to require security in such instances and to such amount as they think fit.

(*g*) To engage professional or other assistance in connection with the business of the Association and subject to the provisions of the Memorandum of Association to pay reasonable fees or remuneration for the same as they may think fit.

(*h*) To appoint any person or persons whether incorporated or not to act as trustee or trustees to accept and hold in trust for the Association any property belonging to the Association or in which it is interested, or for any other purposes, and to execute and do all such deeds and things as may be requisite in relation to any such trust and to provide for the remuneration of such trustee or trustees.

(*i*) To institute, conduct, defend, compound or abandon any legal proceedings by or against the Association or its officers, or otherwise concerning the affairs of the Association and also to compound and allow time for payment or satisfaction of any debts due and of any claims or demands by or against the Association.

(*j*) To refer any claims or demands by or against the Association to arbitration and observe and perform the awards.

(*k*) To make and give receipts, releases and other discharges for money payable to the Association and for the claims and demands of the Association.

(*l*) To affix the seal of the Association to all deeds and documents requiring the same.

(*m*) To determine who shall be entitled to sign on the Association's behalf bills, notes, receipts, acceptances, endorsements, cheques, releases, contracts and other documents.

(*n*) To invest and deal with any of the moneys of the Association not immediately required for the purposes thereof, upon such securities for the time being authorized by law for the investment of trust funds and in such manner as they may think fit, and from time to time to vary or realize such investments, subject nevertheless to the provisions contained in the Memorandum of Association.

(*o*) To enter into all such negotiations and contracts and rescind and vary all such contracts and execute and do all such acts, deeds and things in the name and on behalf of the Association as they may consider expedient for or in relation to any of the matters aforesaid or otherwise for the purposes of the Association.

(*p*) To delegate any of their powers (other than their powers under Article 16 hereof) to Committees consisting of two or more Members of their body and to make and impose upon such Committees such rules and regulations and to vary the same from time to time as they shall think fit.

(*q*) To set up, constitute and organize local branches of the Association, consisting of Members of the Association in such places as they may think fit, and to appoint, or authorize the Members of such local branches to appoint persons as additional members of any local branch and Councils consisting of Members of the Association to control and manage such local branches and to define the powers and duties of such local branches and Councils, and to make and impose by-laws, rules and regulations for the administration and government of such local branches and of such Councils and to delegate any of their powers to such local branches and to such Councils as they may deem fit.

(*r*) To apply for, or oppose the application by others for patents, concessions, rights, charters and legislative acts and authorizations from any government or authority.

(*s*) To appoint at any time and from time to time by power of attorney under the seal of the Association any persons to be the attorneys of the Association for such purposes, with such powers, and for such period and subject to such conditions as the Council may from time to time think fit, but so that the Council shall not be at liberty to delegate to any such attorneys any of the discretions vested in the Council by these presents. Any such appointment may (if the Council think fit) be made in favour of the Members or any of the Members of any local branch established as aforesaid or in favour of any company or of the members, directors, nominees, or managers of any company or firm, and any such power of attorney may contain such provisions for the protection or convenience of persons dealing with such attorneys as the Council think fit, and may authorize any such delegates or attorneys as aforesaid to sub-delegate all or any of the powers, for the time being vested in them.

(*t*) To exercise the powers conferred by Section 79 of the Companies (Consolidation) Act, 1908, and such powers shall accordingly be vested in the Council. And the Association may cause to be kept in any part of the British Empire in which it transacts business a branch register of Members resident in such part of the Empire; and the Council may from time to time make such provisions as they may think fit respecting the keeping of any such branch register.

(*u*) To make provision for compliance with any regulations which may be attached by the Department to the payment of grant.

Proceedings of the Council.

34. The Council may meet together for the dispatch of business, adjourn and otherwise regulate their meetings and proceedings as they think fit, and may determine the quorum necessary for the transaction of business. Until the Council otherwise determine, five Members of the Council shall be a quorum.

35. The Council may elect a Chairman of their meetings and determine the period for which he is to hold office, but if no such Chairman is elected, or if he should not be present at the commencement of any meeting of the Council, the Members of the Council shall select a Chairman from those present for that meeting.

36. The Council may at any time, and the Secretary upon the request of three Members of the Council shall, convene a meeting of the Council. In the case of a meeting convened at the request of three Members the notice of meeting shall state the character of the business to be discussed, and only business of which notice shall be so given shall be discussed at that meeting. Each Member of the Council shall name an address in the United Kingdom at which all notices shall be served upon him, and all notices served at such address shall be deemed to be well served. Questions arising at any meeting of the Council shall be decided by a resolution of the majority of Members present at such meeting. In the event of the votes being equally divided the Chairman shall have a casting vote in addition to the vote to which he is entitled as a Member of the Council.

37. A meeting of the Council for the time being at which a quorum is present shall be competent to exercise all or any of the authorities, powers and discretions by or under the Articles of Association for the time being vested in or exerciseable by the Council generally.

38. The meetings and proceedings of any committee appointed by the Council under Article 33 (*p*) shall be governed by the provisions herein contained for regulating the meetings and proceedings of the Council, so far as the same are applicable thereto, and are not superseded by any regulations made by the Council under Article 33 (*p*).

39. All acts done by any meeting of the Council or by a Committee of the Council or by any person acting as a Member of the Council shall notwithstanding that it shall be afterwards discovered that there was some defect in the appointment of the Council, or such Committee or person acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed and was qualified to be a Member of the Council.

Minutes.

40. The Council shall cause minutes to be duly entered in books provided for the purpose:—

(*a*) Of all appointments of officers;
(*b*) Of the names of the Members of the Council present at each meeting of the Council, and of any Committee of the Council;
(*c*) Of all orders made by the Council and Committees of the Council;
(*d*) Of all resolutions and proceedings of General Meetings and of meetings of the Council and Committees.

41. Any such minutes of any meeting of the Council or of the Committee, or of the Association, if purporting to be signed by the Chairman of such meeting, or by the Chairman of the next succeeding meeting, shall be receivable as *prima facie* evidence of the matters stated in such minutes.

Research.

42. There shall be at all times a Director of Research or other responsible technical officer who shall be appointed by the Council and entrusted with the general direction and supervision of the research work undertaken by the Association.

43. No Member of the Association shall be entitled to require discovery of or any information respecting any such research work, or make use of any such information except in strict accordance with the rules and regulations made by the Council of the Association.

44. Every Member of the Council, Director of Research, officer, or other responsible person employed in the business of the Association shall, before entering upon his duties, sign an undertaking to observe a strict secrecy respecting the progress and results of all researches of which he shall obtain knowledge in exercise of his duties or while occupying such office or in the course of such employment as aforesaid, and not to use or otherwise take advantage in his private capacity of special knowledge so obtained, or put into operation any invention or process of which he shall have obtained knowledge as aforesaid, except, as regards a Member of the Association, to the extent to which, and as and when he shall be entitled so to do in common with other Members of the Association in strict accordance with the rules and regulations made by the Council as provided by these Articles.

45. Nothing in Articles 43 and 44 shall prevent discussion, disclosure or publication as between Members of the Council and of the Association or its officers relating to researches undertaken or proposed to be undertaken by the Association or prevent the use of any information obtained by any Member of the Council or of the Association in the ordinary course of his own business or the continued user of any process already employed in such business though research may subsequently bring such process to the knowledge of the Association subject to any rules and regulations which may be from time to time made by the Council with regard thereto.

46. Every employee of the Association engaged on research or other scientific work shall contract in writing that he will in consideration of his employment hold exclusively for the benefit of and assign to the Association [and the Department or their nominees]* at the cost of the Association all rights and ownership in any discoveries, inventions, designs or other results arising in the course of such employment upon such research or other scientific work.

47. The Director of Research shall not, where a Member of the Association has appealed to the Department under Article 18 proceed with the research referred to in the appeal until the special permission or directions of the Department provided for in Article 18 have been received.

Seal.

48. The Council shall provide for the safe custody of the seal, and the seal shall never be used except by the authority of the Council or a Committee thereof previously given, and in the presence of two Members of the Council at the least, who shall sign every instrument to which the seal is affixed, and every such instrument shall be countersigned by the Secretary or some other person appointed by the Council.

General Meetings.

49. The first General Meeting of the Association shall be held at such time within not less than one month nor more than three months after the incorporation of the Association and at such place as the Council shall determine. Subsequent General Meetings shall be held once in every year at such time (not being more than fifteen months after the last preceding meeting) and place as may be prescribed by the Association in General Meeting, and if no other time or place is prescribed at such time and place as may be determined by the Council.

* NOTE.—The words within brackets will only be added when the Department is making to the Association a grant calculated at a rate higher than pound per pound of the contributions made by the Members of the Association.

50. The General Meetings referred to in the last preceding clause shall be called Ordinary Meetings. All other meetings of the Association shall be called Extraordinary Meetings.

51. The Council may, whenever they think fit, and they shall, on the requisition of not less than Ordinary Members of the Association, forthwith proceed to convene an Extraordinary General Meeting of the Association, and in the case of such requisition the following provisions shall have effect:—

(1) The requisition must state the objects of the meeting and must be signed by the requisitionists and deposited at the office, and may consist of several documents in like form each signed by one or more requisitionists.

(2) If the Council do not proceed to cause a meeting to be held within 21 days from the date of the requisition being so deposited, the requisitionists or a majority of them may themselves convene the meeting, but any meeting so convened shall not be held after three months from the date of the deposit.

(3) If at any such meeting a resolution requiring confirmation at another meeting is passed, the Council shall forthwith convene a further Extraordinary General Meeting for the purpose of considering the resolution; and, if thought fit, of confirming it as a special resolution; and if the Council do not convene the meeting within seven days from the date of the passing of the first resolution, the requisitionists, or a majority of them, may themselves convene the meeting.

(4) Any meeting convened under this clause by the requisitionists shall be convened in the same manner as nearly as possible as that in which the meetings are to be convened by the Council.

52. Seven days' notice to the Members, exclusive of the day when the notice is served or deemed to be served, but inclusive of the day for which notice is given, specifying the place, day and hour of meeting, and in case of special business the general nature of such business shall be given and the notice sent by post or otherwise served as hereinafter provided.

53. Where it is proposed to pass a special resolution the two meetings may be convened by one and the same notice, and it is to be no objection to such notice that it only convenes the second meeting contingently on the resolution being passed by the requisite majority at the first meeting.

54. The accidental omission to give any such notice to or the non-receipt of any such notice by any of the Members shall not invalidate any resolution passed at any such meeting.

Proceedings at General Meetings.

55. The business of an Ordinary Meeting shall be:—

(*a*) To receive and consider the accounts, the balance sheet and the reports of the Council and the Auditors.

(*b*) To elect Members of the Council and other officers in the place of those retiring by rotation.

(*c*) To appoint an Auditor or Auditors and fix his or their remuneration.

(*d*) To transact any other business which under these presents ought to be transacted at an Ordinary Meeting.

All other business transacted at an Ordinary Meeting and all business transacted at an Extraordinary Meeting shall be deemed special. If any Member has any proposal or any matter which he wishes to make or bring before an Ordinary Meeting he shall give 14 days' written notice thereof to the Secretary.

56. Every meeting of the Association shall be presided over by the Chairman of the Council, and in his absence the meeting shall elect a Chairman from the Members of the Council then present or if none be present from the Members of the Association.

57. For all purposes the quorum of a General Meeting shall be five Ordinary Members personally present.

58. No business shall be transacted at any General Meeting unless the quorum requisite shall be present at the commencement of the business.

59. If within half an hour from the time appointed for the meeting a quorum is not present, the meeting if convened upon such requisition as aforesaid, shall be dissolved, but in any other case it shall stand adjourned to the same day in the next week at the same time and place, and if at such adjourned meeting a quorum is not present, those Ordinary Members who are present shall be a quorum and may transact the business for which the meeting was called.

60. Every question submitted to a meeting shall be decided in the first instance by a show of hands, and in the case of an equality of votes the Chairman shall both on a show of hands and at a poll have a casting vote in addition to the vote to which he may be entitled as an Ordinary Member. Every Ordinary Member shall have one vote and no more, and no other Member shall be entitled to vote. The person nominated by a corporation under the provisions of Article 10 shall alone be entitled to vote for the corporation on a show of hands.

61. No Ordinary Member shall be entitled to vote if his subscription is in arrear for the space of one month.

62. At any General Meeting, unless a poll is demanded by the Chairman or by five Members entitled to vote, a declaration by the Chairman that a resolution has been carried or carried by a particular majority or lost, or not carried by a particular majority, and an entry to that effect in the book of proceedings of the Association shall be conclusive evidence of the fact without proof of the number or proportion of the votes recorded in favour of or against such resolution.

63. If a poll is demanded as aforesaid, it shall be taken in such manner and at such time within fourteen days and at such place as the Chairman of the meeting directs, and either at once or after an interval or adjournment or otherwise, and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded. The demand for a poll may be withdrawn.

64. On a poll votes may be given either personally or by proxy. A proxy shall be appointed in writing under the hand of the appointor, or of his attorney, or, if such appointor is a corporation, under the signature of a Director. Any instrument appointing a proxy may be printed, or in writing, or partly printed and partly in writing, and duly stamped, and shall be as nearly as may be in the following form:—

THE BRITISH RESEARCH ASSOCIATION

I of being a Member of the above Association hereby appoint of whom failing of , as my proxy to vote for me and on my behalf at the Ordinary or Extraordinary General Meeting of the Association to be held on the day of General Meeting of the Association to be held on the day of 19 , and at any adjournment thereof.

Signed by the said this day of 19 .

In the presence of

65. No person shall act as proxy unless he is an Ordinary Member of the Association, or unless he is appointed to act at the meeting for a corporation, and the instrument appointing him shall be deposited at the office not less than twenty-four hours before the time of holding the meeting at which he proposes to vote.

66. The Chairman of a General Meeting may with the consent of the meeting adjourn the same from time to time and from place to place, but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place.

67. Any poll demanded on the election of a Chairman of a meeting or on any question of adjournment shall be taken at the meeting and without adjournment.

68. The demand for a poll shall not prevent the continuance of a meeting for the transaction of any business other than the question on which a poll has been demanded.

69. The Council shall cause true accounts to be kept of the sums of money received and expended by the Association, and the matters in respect of which such receipts and expenditure take place, and of the assets, credits and liabilities of the Association.

70. The books of account shall be kept at the office or at such other place or places as the Council think fit.

71. The Council may from time to time determine at what times and places, and under what conditions or regulations, the accounts and books of the Association or any of them shall be open to the inspection of the Members.

72. At the Annual General Meeting in every year the Council shall lay before the Association a statement of account showing the receipts and expenditure of the Association for the period since the preceding account (or in the case of the first account since the incorporation of the Association) made up to a date not more than six months before such meeting.

73. A balance sheet shall be made out and laid before the Association at the Annual General Meeting in every year, made up to a date not more than six months before such meeting. The balance sheet shall be accompanied by a report of the Council upon the general state of the Association.

74. A printed copy of the accounts, balance sheet, and report shall ten clear days previously to such meeting, be served on every member of the Association entitled to receive notices of General Meetings in the manner in which notices are hereinafter directed to be served, and a copy shall also be sent to the Department.

Audit.

75. Once at least in every year the accounts of the Association shall be examined and the correctness of the balance sheet ascertained by one or more properly qualified Auditor or Auditors.

76. The Association at each Ordinary General Meeting shall appoint Auditors to hold office until the next Ordinary General Meeting, and the following provisions shall have effect, that is to say:—

(1) If an appointment of Auditors is not made at an Ordinary General Meeting the Board of Trade may on the application of any Member of the Association appoint Auditors for the current year and fix the remuneration to be paid to them by the Association for their services.

(2) A Member of the Council or officer of the Association shall not be capable of being appointed Auditor of the Association.

(3) The Members of the Council may fill any casual vacancy in the office of Auditor, but while any such vacancy continues the surviving or continuing Auditor or Auditors (if any) may act.

77. The remuneration of the Auditors shall be fixed by the Association in General Meeting.

78. (1) Every Auditor of the Association shall have a right of access at all times to the books and accounts, and vouchers of the Association, and shall be entitled to require from the Members of the Council and officers of the Association such information and explanation as may be necessary for the performance of the duties of the Auditors.

(2) The Auditors shall make a report to the Members on every balance sheet laid before the Association in General Meeting during their tenure of office and the report shall state:—

(*a*) Whether or not they have obtained all the information and explanations they have required; and

(*b*) Whether in their opinion the balance sheet referred to in the report is properly drawn up so as to exhibit a true and correct view of the state of the Association's affairs according to the best of their information and explanations given to them and as shewn by the books of the Association.

79. The balance sheet shall be signed on behalf of the Council by two Members of the Council of the Association, and the Auditor's report shall be attached to the balance sheet or there shall be inserted at the foot of the balance sheet a reference to the report, and the report shall be read before the Association in General Meeting, and shall be open to inspection by any Member.

80. Every account of the Council, when audited and approved by a General Meeting, shall be conclusive except as regards any error discovered therein within six months next after the approval thereof. Whenever any such error is discovered within that period, the account shall forthwith be corrected and thenceforth shall be conclusive.

Notices.

81. A notice may be served by the Association upon any Member either personally or by sending it through the post in a prepaid envelope or wrapper addressed to such Member at his registered place of address.

82. Each Member shall from time to time notify in writing to the Association an address in the United Kingdom which shall be deemed his registered place of address within the meaning of the last preceding clause. If he shall not have named such an address he shall not be entitled to any notices.

83. Any notice required to be given by the Association to the Members or any of them and not expressly provided for by these presents shall be sufficiently given, if given by advertisement in one London morning newspaper.

84. Any notice required to be, or which may be given by advertisement shall be advertised once in one London newspaper.

85. Any notice sent by post shall be deemed to have been served on the day following that on which the envelope or wrapper containing the same is posted, and in proving such service it shall be sufficient to prove that the envelope or wrapper containing the notice was properly addressed and posted. A certificate in writing signed by any Manager, Secretary or other officer of the Association that the envelope or wrapper containing the notice was so addressed and posted, shall be sufficient evidence thereof.

86. The signature to any notice to be given by the Association may be written or printed.

87. Every notice or application to the Council or the Secretary or the Association, except where otherwise specifically provided, shall be sufficient if the same be signed by the person or persons giving or making the same, and be given to the Secretary or be left at the office addressed to him between the hours of ten in the forenoon and four in the afternoon of any working day, excepting Saturday, or be forwarded to him at

such office by post prepaid, and every person giving or making such notice or application shall be entitled to require an acknowledgment by the Secretary of the receipt of such notice or application.

Indemnity. re.

88. Every Member of the Council, Manager, Secretary and other officer or servant of the Association shall be indemnified by the Association against, and it shall be the duty of the Members of the Council, out of the funds of thee Association, to pay all costs, losses and expenses, including travelling expenses, which any such officer or servant may incur or become liable to by reason of any contract entered into or act or thing done by him as such officer or servant or in any way in the discharge of his duties.

89. No Member of the Council or other officer of the Association shall be liable for the acts, receipts, neglects or defaults of any other Member or officer, or for joining in any receipt or other act of conformity, or for any loss or expenses happening to the Association through the insufficiency or deficiency of title to any property acquired by order of the Council for or on behalf of the Association or of the insufficiency or deficiency of any security in or upon which any of the moneys of the Association shall be invested or for any loss or damage arising from the bankruptcy, insolvency, or tortious act of any person with whom any moneys, securities or effects shall be deposited, or for any loss occasioned by any error of judgment or oversight, omission or default on his part or for any other loss, damage or misfortune whatever which shall happen in the execution of the duties of his office or in relation thereto unless the same happen through his own dishonesty.

Arbitration.

90. Subject to the provisions of Article 18, if and whenever any difference shall arise between the Association and any of the Members or their respective representatives touching the construction of any of the Articles herein contained, or any act, matter, or thing made or done or to be made or done or omitted or in regard to the rights and liabilities arising hereunder or arising out of the relation existing between the parties by reason of these presents or of the Statutes or any of them, such difference shall be forthwith referred to two Arbitrators—one to be appointed by each party in difference—or to an Umpire to be chosen by the Arbitrators before entering on the consideration of the matters referred to them, and every such reference shall be conducted in accordance with the provisions of the Arbitration Act, 1889.

Names, Addresses and Description of Subscribers—

DATED the day of 1918

Research Association Circular 3. (Revised.)

CONDITIONS AS TO THE PAYMENT TO RESEARCH ASSOCIATIONS BY THE COMMITTEE OF COUNCIL.

Draft Letter.

THE SECRETARY TO THE BRITISH RESEARCH ASSOCIATION.

SIR,—I am directed by the Committee of the Privy Council for Scientific and Industrial Research to address you on the subject of the grant which they are prepared to make to the British Research Association for the promotion of research in connection with the Industry.

The conditions attached to the grant to be made by the Committee of Council are set out below. They are based upon the assumption that the Association will raise from its members in each year of the period for which the grant is made, a sum of not less than and not more than . Should the Association raise additional sums, the Committee of Council will be prepared to consider the question of paying to the Association such further sums as may be hereafter agreed between the Committee of Council and the Council of the Association. Should, however, the sum received by the Association in respect of any one or more years of the period be less than , the Committee of Council reserves to itself full discretion to reduce the total amount of the grant to be paid to the Association under the conditions specified in this letter and also to modify those conditions, provided that the Association will not be held liable to refund on this account any payment which may have actually been made to it out of the grant.

So far as the conduct of the affairs of the Association is concerned, it is the intention of Government that this shall be in the hands of the Association itself, subject to the Statutory and other duties imposed upon the Association by the conditions and by the Memorandum and Articles of Association.

The conditions to be attached to the grant are as follows:—

(1) There shall be payable a sum of in respect of a period of five years dating from provided that the Association raise a sum of at least in respect of and in each year of the period in question. The proportion of the said which will be payable in respect of any one year of the above-mentioned period shall not exceed one-fifth of that sum unless otherwise determined by the Committee of Council after consultation with the Council of the Association. This sum will be paid to the Association in equal quarterly instalments as soon as possible after the 30th June, the 30th September, the 31st December and 31st March in the year in question.

(2) A further sum of for each additional pound over and above the sum of raised in respect of any one year of the period will be payable provided that the additional payment so made in respect of that year shall not exceed . This further sum, if any, will be paid to the Association as soon as possible after the close of the year upon the receipt of a statement duly certified by the authorized Officer of the Association and showing the amounts actually received by the Association in respect of that year.

(3) The general scheme of research for each year will be submitted in advance to the Committee of Council, together with an estimate of the expenditure to be incurred thereon during the year.

(4) If any research is undertaken for the benefit of an individual firm or for a group of firms, the Association will enter into an agreement with the firm or firms concerned, in a form to be approved by the Committee of Council.

(5) Any expenditure by the Association on buildings or permanent equipment beyond a sum of in any single year must be approved by the Committee of Council before it is incurred. Plans and estimates, as well as copies of the tenders submitted, will be referred to the Committee of Council for approval in advance.

(6) The Committee of Council shall have access to any laboratories, workshops, or other premises owned, leased, or loaned to, or controlled by the Association, and have power to inspect the work in progress therein and all documents or records connected therewith.

(7) All rights and ownerships in any discoveries and inventions arising from the work of the Association shall be the property of the Association and shall be held by the Association for the benefit of members, always provided that the Department, acting in the national interest may,

(*a*) after consultation with the Council of the Association secure that the results of investigations shall be communicated to other industries on such terms of payment and such other conditions as the Department, after consultation with the Council of the Association concerned, and with other co-operating bodies and persons, deem fair and reasonable.

(*b*) prohibit the communication of any results to any foreign person or body or to any person or body under foreign control as defined in the Model Articles of Association (*see* "Research Association 2.")

In order that the Department may determine whether any action is required by the national interest the Council of the Association shall make arrangements by which the results of investigation as obtained from time to time shall not become available until after communication to the Department.

(8) The Association shall enter into an agreement in writing with each employee engaged on research or other scientific work that he will in consideration of his employment hold exclusively for the benefit of and assign to the Association (and the Committee of Council or their nominees,*) at the cost of the Association, all rights and ownership in any discoveries, inventions, designs or other results arising in the course of such employment upon such research or other scientific work.

(9) The Association will keep accounts in such form as the Committee of Council may direct, and the accounts will be open to inspection by the Committee of Council.

(10) The Association will submit to the Committee of Council an annual report of its proceedings and of the progress of all research and scientific work being undertaken by or on behalf of the Association, together with copies of duly audited accounts.

(11) Payment of the grant shall be conditional upon the due performance of the Association of these conditions and upon the due prosecution of research. In the event of any default the Committee of Council may, in their discretion, reduce or withhold the grant.

I am, sir, your most obedient servant,

Research Association Circular 4.

THE METHOD OF SUBSCRIPTIONS TO RESEARCH ASSOCIATIONS.

1. *The Basis of Subscriptions.*

In the leaflet describing the Government scheme for industrial Research (Research Association I.) it is stated that "the method of assessing the subscription of each firm will have to be negotiated with each Industry or section of an Industry which agree to combine for the purposes of research, but the intention is that firms should contribute on a basis proportionate to their size. Thus the small firm will contribute less than the large firm, yet it will have the same privileges, though as a rule it will not in the nature of the case have the same facilities for exploiting the results of research."

It is certain that most British industries are conducted on so large a scale that if a majority of the firms engaged in each of them join the appropriate Research

*NOTE.—The words within brackets will only be added in those exceptional cases in which the Department is making to an Association a grant calculated at a rate higher than pound for pound of the Contribution made by the Members of the Association.

Association and contribute in proportion to their size, the burden on any single firm will in many cases be comparatively small—less, indeed, than the premiums for Fire, Employers' Liability or National Health Insurance.

For this reason, it will normally be sufficient if a Research Association levies subscriptions on such a basis that a near approximation to the correct amount is raised from each firm. There is no need, even if it were possible, to make careful calculations in order to ensure that the burden is distributed quite equitably and in exact proportion to the size of each of the contributing firms.

It may be noted that experience has shown that, in some cases in which the industry is not a very large one or the initial expenditure on research is not expected to be on any considerable scale, it has been found sufficient to arrange for the levy of uniform subscriptions from the firms or individuals joining the association. Such cases are, however, somewhat exceptional, and the following paragraphs deal with the more numerous associations for which proportionate subscriptions are likely to prove more suitable.

2. *Estimation of the Size of Businesses.*

As soon as an attempt is made to determine the relative sizes of the firms constituting a Research Association, the difficulty arises that it is necessary to select a standard by which the size of each can be measured. A number of different standards suggest themselves:—

(*a*) The total capital employed.
(*b*) The average annual profits over a definite period.
(*c*) The annual wage bill.
(*d*) The number of persons employed.
(*e*) The volume of the output.
(*f*) The value of the output.
(*g*) The amount of plant.

3. *Homogeneous Firms.*

If all the firms in the Association carry on businesses of similar character, there will be little difficulty in selecting the most suitable basis of subscription. Almost any one of the standards mentioned above, except (*b*), may be chosen, the particular one adopted depending on the nature of the business. If a Federation of Employers exists in the industry, it will be most convenient to adopt the basis they employ for the assessment of their ordinary subscriptions.

4. *Businesses differing in Character.*

It will very often happen that a Research Association will include firms carrying on businesses differing considerably from one another, but having very closely related interests. Thus, an Iron and Steel Association might include makers of Bessemer Steel and puddled iron; a Pottery Association would probably include makers of china, of earthenware and of sanitary ware; a Cotton Association would include cotton growers, spinners, manufacturers of cloth, of lace and of hosiery, dyers, bleachers and calico printers; and a Wool Association or a Non-ferrous Metals Association would be no less complex in structure.

It is evident that the method of deciding the basis of assessment must often be a difficult matter, since it is unlikely that any single standard can be employed for determining the relative sizes of diverse branches of a single great industry. The difficulty is increased by the fact that in some idustries there are Federations of Employers, each of which has selected a basis of assessment for its own purposes which is not universally suitable for all the industries co-operating with it in the Research Association.

To take an example, the Federation of Master Cotton Spinners' Associations bases its ordinary levy on the number of spindles owned by each of its constituent firms, the Federation of Calico Printers bases its subscription on the number of machines in each business, and the Federation of Dyers takes as its basis of subscription the annual Wage Bill. All these varying standards must, however, be reconciled so as to provide a convenient and reasonably equitable basis of subscription in the Cotton Research Association which includes all of them.

5. *Conditions Which Standards Must Fulfil.*

The standards selected for measuring the size of businesses in order to determine the basis of subscription must be:—

(*a*) easily accessible,
(*b*) fairly constant,
(*c*) readily comparable,

not only as between businesses of exactly the same kind, but also between dissimilar but closely linked businesses.

6. *Consideration of Each Standard.*

(*a*) Capital.—(i) At once the difficulty appears of defining exactly what is meant by the capital of a firm. Does it include preference shares, debentures, bank overdrafts and loans repayable at short notice? The reply to this appears to be that it should include all the capital normally employed in the business, that is to say, ordinary and preference shares, debentures and loans of a semi-permanent character, the amount of these last being determined by calculating the average indebtedness as disclosed by the balance sheets of, say, the three years preceding the assessment.

(ii) It is advisable that all the firms in the Association should be divided for purposes of assessment into a small number of groups, each of which has within certain rather wide limits about the same capital. Thus all firms with a capital of £20,000 or less might form a single group, those with from £20,000 to £40,000 capital another group, and so on.

As the size of the firms increased, the range of capital in a single group would become greater and greater, until in the case of the very large firms, or combinations of firms, those whose capital did not differ by more than £500,000 or £1,000,000 might be included in the same group.

Such a plan as this has, of course, no claims to be exact, but it has the advantages that it is simple and convenient; further, it does not lead to inquisitorial inquiries from the Association. The responsibility for the statement of the capital of any firm should rest on the firm's own accountant, although the Association would necessarily reserve the right of employing its own accountant to check the statement in case of a serious dispute; it is improbable, however, that the need for such a check would ever arise.

(iii) Once the capital of each firm in the Association has been ascertained, no further difficulties arise, since the other conditions that it is fairly constant and readily comparable as between one firm and another are satisfied.

(*b*) Annual Profits.—This standard is quite impracticable, as it fails to satisfy the conditions that the basis shall be easily accessible and fairly constant.

(*c*) Annual Wage Bill.—At first sight this method is attractive, since there are usually no strong reasons for concealing the total amount of wages paid, and the amount is fairly constant. It would not, however, afford a definite guide to the size of each firm engaged in different branches of the same great industry where those branches are dissimilar.

Thus, a firm engaged in making very cheap woollen cloth may pay the same total amount of wages as one making the most expensive cloth, but the total capital involved would probably be much less. Again, a cotton weaving mill with a capital of £25,000 would probably have at least as large an annual wage bill as a cotton spinning mill with several times its capital.

(*d*) NUMBER OF PERSONS EMPLOYED.—There are precisely the same objections to taking this as the basis of assessment in certain cases as there are to adopting the annual wage bill, since the two are so closely related. There is, further, the difficulty that the proportion of men and women, and of adults and young persons, vary in different branches of the same industry.

(*e*) and (*f*) OUTPUT.—This basis might be adopted in some cases as in coal mining, but difficulties would arise where exact statistics of output are not kept. There would also be cases in which some firms might prefer not to disclose particulars relating to the value or volume of their output.

(*g*) THE AMOUNT OF PLANT.—Although this standard may be excellent for businesses of the same character, it is impracticable in cases where the separate businesses are of different kinds. For example, the number of spindles in a spinning mill cannot be compared with the vats, dyeing-machines, etc., in a dyeworks.

7. Capital often the Most Suitable Standard.

A consideration of all the different standards which have been mentioned suggests, therefore, that the most practical method of raising funds for a Research Association is , in many cases, to base the subscription of each firm on the amount of capital it employs in its business. There are objections to this, some of which have been dealt with above, but no other factor complies so fully with the necessary conditions where dissimilar branches of the same industry are concerned.

8. The Compounding of Subscriptions by Federations of Employers.

Serious difficulties arise in fixing suitable bases of assessment when Federations of Employers engaged in different branches of an industry join the same Research Association and agree to compound their subscriptions. These difficulties must, however, be faced, as the compounding of the subscriptions of members of an Employers' Association leads to simplicity of administration, to equitable assessments for firms engaged in similar businesses, and to economy of effort in the task of securing general co-operation.

Whether a Federation has adopted the amount of plant, wages, output or any other comparable quantity as a basis for the assessment of the ordinary subscriptions of its members, the proper course for the Research Association appears to be to accept the method employed by the Federation and to try to bring it into terms of capital. Thus, if the number of spindles or looms is the basis, calculations must be made as to the approximate capital represented by a spindle or a loom in a mill and the assessment based on that; if the wage bill is the basis, then a relation between the wage bill and the capital of several typical concerns must be determined. In any case it is essential that the Employers' Federation, when such exists, shall in each case be taken fully into consultation, in order that its members may have the opportunity of learning that the levy made upon them is equitable.

REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH OF CANADA

For the Year ending March 31, 1920

OTTAWA
THOMAS MULVEY
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1920

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